STORMWATER ASSESSMENT
&
EDUCATION REPORT

of the

Watershed Improvement and Education Project

CITY OF GLENWOOD SPRINGS

In GARFIELD COUNTY, COLORADO

Prepared for:
ROARING FORK CONSERVANCY,
CITY OF GLENWOOD SPRINGS,
and the
COLORADO DEPARTMENT OF PUBLIC HEALTH & ENVIRONMENT'S
WATER QUALITY CONTROL DIVISION
Under a Section 319 Grant

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PREFACE

This report presents the results of a **Watershed Improvement and Education Project** for the City of Glenwood Springs, Colorado. This Report was prepared by Matrix Design Group, Inc. of Denver, Colorado at the request of the Roaring Fork Conservancy in cooperation with the Colorado Department of Public Health & Environment's Water Quality Control Division.

Copies of this report are available for public inspection or distribution, for a nominal fee, at the offices listed below or on their website.

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This Stormwater Evaluation Report was prepared under the direct supervision and direction of the undersigned whose seal as a Professional Engineer is affixed:

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Project Purpose

This ***Stormwater Assessment and Education Report*** was completed by Matrix Design Group for the City of Glenwood Springs through a grant from the U.S. Environmental Protection Agency, administered by the Water Quality Control Division (WQCD), and sponsored by the Roaring Fork Conservancy. The following project partners also contributed to the completion of this report: the City of Glenwood Springs, the Colorado River Water Conservation District, and Glenwood Springs High School. The objective of this report is to:

1. *Evaluate non-point source pollution to waterways, and*
2. *Develop an education project on the stormwater impacts to water quality in the Glenwood Springs area.*

Value of this Study

This project provided the following new tools to the City for management of stormwater runoff:

1. **GIS Database of Stormwater Infrastructure**, including pipe sizes, type and location. (Prior to this study, the City had limited information on manholes and inlets, but no comprehensive database of public and private storm drains.)
2. **Electronic Mapping of Drainage Basins**, within the City boundaries and contributing off-site basins from the surrounding hillsides. A fold-out map of the entire City and contributing hillsides is included at the end of this report, along with six 11x17 color maps of the City showing basin boundaries, existing infrastructure and recommended stormwater controls. (Prior information was available in hard-copy only of basins originally delineated for mud flows by ESA Geotechnical Consultants and ARIX in a 1982 *Drainage and Debris Control Plan*. The U.S. Army Corps of Engineers restudied the drainage basins in a 1997 Flood Insurance Study of hillside debris flow. This report began with the previously delineated basins and carried the basins through the City and specifically examined stormwater basins inside the City of Glenwood Springs.)
3. **Identification and Inventory Major Storm Drain Outfalls**. Using the database of storm pipes and topography, stormwater outfalls were identified and classified according to their drainage basins and contributing land use areas. These outfalls were correlated with the watershed boundaries.
4. **Field Confirmation of Stormwater Outfalls**. Matrix personnel toured the City with the assistance of City Staff to map storm drains and previous efforts for stormwater controls and water quality management. Manholes were opened and pipes were measured to develop an accurate database of stormwater controls. A photo inventory of stormwater controls is included in this report, along with the citywide mapping.
5. **Recommendations for Stormwater Improvements.** Once the City stormwater system was mapped and analyzed, recommendations were made for stormwater

infrastructure, management and ordinances. This report provides a comprehensive summary of stormwater regulations, management techniques and a listing of controls to improve the quality of stormwater runoff.

6. **Educational Materials on Non-Point Source Pollution** have been provided to educate the community on the impacts of urban runoff and to implement controls to halt the degradation of the Roaring Fork and Colorado River's water quality throughout the City.

This report is a first step toward meeting upcoming drainage regulations, and more importantly, protecting the Roaring Fork and Colorado River watersheds that are so highly valued by the Glenwood Springs community. Although this report provides many recommendations to the City and comprehensive mapping of the storm drainage infrastructure, more detailed drainage master plans should be developed to identify capital improvement projects that will reduce the City's susceptibility to periodic flooding, debris flow damage, ice build-up, and to comprehensively improve the quality of stormwater runoff.

Project Need

Drainage is frequently ignored but can have a major impact on the Glenwood Springs community. The City is highly susceptible to damage from stormwater runoff resulting in mud and debris flows as witnessed on a large scale in 1977 and 1981. The solution at the time was to figure a way to convey this mud into the rivers. New trends in Clean Water Act regulation are focused on degradation of stream water quality as the result of sedimentation and urban runoff. Glenwood Springs, located at the confluence of the Roaring Fork and Colorado Rivers, takes great pride and character from its proximity to the pristine waters through the heart of town. The *Gold Medal* waters of the Roaring Fork River, along with the Colorado River, are irreplaceable amenities that can be damaged by pollutants carried to the stream system by stormwater runoff. A paradigm shift has occurred within the stormwater management community to change from a philosophy of *sending everything into the rivers* for dilution, to a vision of *protection of rivers and streams* by holding back pollutants in the runoff.

Glenwood Springs is a mountain community without extensive stormwater infrastructure or federally mandated stormwater programs. Nonetheless, the City is experiencing the effects from urban stormwater runoff, particularly given exploding trends in population growth and land development. The effect of non-point source pollution on the river water quality is often significant, given the dramatic changes occurring across the urban landscape. The City of Glenwood Springs requires stormwater management practices for certain activities. However, it does not have a comprehensive stormwater plan, resulting in an unspecified pollutant load entering both the groundwater table and river. Understanding the impact of stormwater runoff on water quality and developing a recommended plan for managing such runoff is crucial to protecting the health of the rivers.

Stormwater Regulations

There is an opportunity to improve the management of stormwater runoff in Glenwood Springs. The federally mandated National Pollutant Discharge Elimination System (NPDES) stormwater regulations under the Clean Water Act do not yet require Glenwood Springs to participate in the permit program, but plans indicate the Glenwood Springs will likely be required to address stormwater quality sometime within the next five years.

Although Glenwood Springs is not a "Phase II Community," this report has been designed and formatted to prepare the City for eventual inclusion in the Clean Water Act NPDES program. The report is sub-divided into six categories that have been established by the Federal Government and are the basis for improving stormwater runoff water quality:

1. Public Education and Outreach on Stormwater Impacts.
2. Public Involvement/Participation.
3. Illicit Discharge Detection and Elimination.
4. Construction Site Program.
5. Post-Construction Stormwater Management.
6. Pollution Prevention/Good Housekeeping for Municipal Operations.

<u>Recommendations</u>
The next step after this study will be to design and implement stormwater controls, and to assess the effectiveness of improved stormwater management and "Best Management Practices" (BMP's). Such improvements may include development of more and better detention and treatment facilities, use of wetland and riparian buffer systems, establishment of a stormwater quality control program, and the incorporation of new stormwater drainage ordinances.

The following steps should be undertaken to improve the quality of stormwater discharges and prevent periodic flooding and damage caused by stormwater runoff:

1. <u>Develop a Drainage Infrastructure Master Plan</u> that specifically identifies deficiencies in the drainage system and proposes new infrastructure.
2. <u>Prioritize</u> the infrastructure capital improvements.
3. <u>Develop Budget and Funding</u> mechanisms to implement the Drainage Infrastructure Master Planned improvements. To fund storm drainage capital improvements and necessary drainage maintenance, a newer approach that is finding favor in many cities is the creation of a ***Stormwater Drainage Utility***, which bills the "users" (residents) of storm sewer drainage improvements an appropriate amount each month or quarter, similar to billing for sanitary sewer.
4. <u>Educate the Community</u> on the implications of urban stormwater runoff and better stormwater management techniques.

Opportunities in Glenwood Springs for better Stormwater Management include:

- ✓ Emphasize Stormwater Management in Ordinances
- ✓ Improve Drainage Conveyance (Pipes & Culverts) to reduce flooding
- ✓ Stormwater Detention/Retention Ponds to prevent injury to downstream properties caused by upstream development
- ✓ Sedimentation Ponds to capture mud and debris flow
- ✓ Water Quality Treatment Ponds to improve the quality of stormwater runoff
- ✓ Better Erosion Control practices during construction to improve water quality

1. INTRODUCTION

1.1 Acknowledgement

The Roaring Fork Conservancy's (Conservancy) mission is to protect and preserve the streams and rivers within the Roaring Fork River watershed. The non-profit organization is involved in initiatives to measure the health of the Roaring Fork River, enhance riparian and aquatic habitat, and lead environmental programs. Stormwater runoff can have a major impact on the stream system, and therefore, the Conservancy is very concerned and interested in better management of water quality from urban stormwater runoff.

The Conservancy applied to the Colorado Water Quality Control Division for a grant to evaluate non-point source pollution and develop an education project on the stormwater impacts to water quality in the Glenwood Springs area. The Conservancy formed a partnership with the City of Glenwood Springs, Colorado River Water Conservation District, and Glenwood Springs High School in January 2002 to develop a cooperative relationship for evaluation of stormwater runoff sources for quality and composition. The State of Colorado awarded the Roaring Fork Conservancy a grant under Section 319 of the Federal Clean Water Act in August 2002. The resulting ***Watershed Improvement and Education Project*** has two main components:

1. Evaluation of non-point source pollutants and developing recommendations for implementation of "Best Management Practices" (BMPs) in the City of Glenwood Springs, and

2. Development of educational activities to include a non-point source pollution curriculum at Glenwood Springs High School, and public outreach focused on preventative strategies to minimize soil erosion and stormwater runoff.

The Section 319 grant provides the means to develop a paradigm for educating the community on stormwater controls, and ultimately help protect the vital water quality of the Roaring Fork and Colorado Rivers. This project is designed to educate not only the Glenwood Springs community, but also other small mountain communities in the Roaring Fork Valley and other Colorado Western Slope watersheds.

The Colorado Division of Wildlife, the Colorado Department of Transportation, Garfield County, and the Town of Basalt, which recently completed a similar project, also support this Watershed Improvement and Education Project.

1.2 Problem Identification

Glenwood Springs's concerns with stormwater have been typically related to local flooding. Residents complain when mud washes down the hillside, their basements flood, utilities are washed away, or roads become impassable. The community suffers when catastrophic floods cause widespread damage to property and loss of life. However, few people are keenly aware of the negative water quality impacts that stormwater has on the rivers, streams and lakes on a regular basis by degrading water quality and the aquatic ecosystem. Stormwater runoff will carry urban pollutants into the rivers runoff and can have significant impacts on the receiving waters of the Roaring Fork and Colorado Rivers running through the heart of the City.

Many people are familiar with the environmental impacts from municipal and industrial wastewater discharges; however, few fully understand the environmental impacts attributable to ordinary stormwater runoff from urban areas. Studies have shown that runoff from development can contain significant quantities of the same general types of constituents that are found in wastewater and industrial discharges.

The impacts of stormwater on streams fit into four general categories:

1. <u>Stream Hydrology</u>: Urban development affects the environment through changes in the size and frequency of storm runoff events, changes in base flows of the stream, and changes in stream flow velocities during storms. Peak discharges into a stream can increase from urbanization due to a decrease in infiltration of rainfall into the ground, and loss of buffering vegetation and resultant reduced evapotranspiration. This results in more surface runoff and larger loads of various pollutants found in urban stormwater.

2. <u>Stream Morphology</u>: When the hydrology of the stream changes, it results in changes to the physical characteristics of the stream. Such changes include streambed degradation, stream widening, and streambank erosion. As the stream profile degrades and the stream tries to widen to accommodate higher flows, bank erosion increases along with increases in sediment loads.

3. <u>Stream Water Quality</u>: Water quality is impacted through urbanization as a result of erosion during construction, changes in stream morphology, and transport of accumulated deposits from the urban landscape into the river. Water quality problems include turbid water, nutrient enrichment, bacterial contamination, organic matter loads, metals, salts, temperature increases, and increased trash and debris.

4. <u>Aquatic Ecology</u>: Pollutant loading from stormwater runoff can significantly alter aquatic ecology, and if left untreated, could diminish aquatic conditions to a level that would threaten the Roaring Fork River's *Gold Medal* fishery classification.

Urbanization affects stormwater runoff by increasing the following:

- The volumes and rates of surface runoff,
- The concentrations and the types of pollutants,
- The amount of pollutants carried to receiving waters.

Urbanization causes a reduction in open land areas, an increase in impervious areas, and accelerated surface runoff (which reduces flooding around development, but increases downstream riverine flooding and reduces water quality). The influx of commercial, residential, and industrial products into an urban area such as Glenwood Springs often brings new pollutants that result in increased concentrations of these pollutants in stormwater. Additional impervious areas can make pollutants easier to wash off the surface and quicken their conveyance through the watershed. The cumulative effect results in much larger loads, and in the delivery of certain pollutants, such as petroleum-based products, not normally found in non-urban and non-industrial runoff.

1.3 Purpose and Scope

This Stormwater Evaluation Report specifically addresses stormwater runoff in the City of Glenwood Springs. It also provides a useful case study for other towns and counties to use as a basis for developing local stormwater runoff water quality controls. Although Glenwood Springs is not currently required to develop a stormwater quality control plan, the Phase II National Pollutant Discharge Elimination System (NPDES) stormwater regulations will eventually require stormwater programs from every community. This plan is a proactive approach for the City of Glenwood Springs to begin protecting its receiving waterways before they are irreversibly degraded.

Need for Stormwater Controls

Glenwood Springs is a mountain community without extensive stormwater infrastructure or federally mandated stormwater programs. The City is nonetheless experiencing the effects from urban stormwater runoff, particularly given exploding trends in population growth and land development. Within or near the Roaring Fork and Colorado Rivers, degradation activities have included the following:

- A growing number of contributors to non-point source pollution runoff,
- Increased residential, commercial and industrial improvements along the river,
- Construction and use of roadway corridors and bridges in or alongside rivers,
- Filling of the river channel and floodplain,
- Degradation and removal of natural vegetation, and
- Recreational use (rafting and angling) and recreation facility development (golf course).

The effect of non-point source pollution on the river water quality is often significant, given the dramatic changes occurring across the urban landscape. The City of Glenwood Springs requires stormwater management practices for certain activities. However, it does not have a comprehensive stormwater plan, resulting in an unspecified pollutant load entering both the groundwater table and river. Potential pollutants in the stormwater runoff include suspended sediments, bacteria, nitrogen, phosphorus, and dissolved metals. The ***Colorado Non-point Source Pollution Assessment Report and Management Plan*** has identified stretches of the Roaring Fork River that have elevated metals concentrations. Understanding the impact of stormwater runoff on water quality and developing a recommended plan for managing such runoff is crucial to protecting the health of the rivers.

Water Quality in the Project Area

The Colorado Department of Health Water Quality Control Division has given the following classifications for the Roaring Fork River: aquatic life is Class 1 – cold, recreation is Class 1, dissolved oxygen minimum standard is 6.0mg/1, pH range is between 6.5 and 9.0, and the fecal coliform maximum level is 200 count/100ml.

While the Colorado Division of Wildlife has classified the Roaring Fork River from the Crystal River to the Colorado River as “Gold Medal” waters, signifying the excellent quality of its fishery, it is facing strong development pressures that typically introduce disturbance of riparian and aquatic habitat and a decline in water quality.

With the pressures of population growth and urban development in the Roaring Fork Valley, which cause increased point source discharge loads and non-point source runoff, it is important to use the best practices and technology available to maintain water quality and limit degradation of beneficial uses. Although the Roaring Fork main stem and most of its tributaries are classified by the State as Class 1 Cold Water Aquatic Life, and Class 1 Recreation, Water Supply and Agriculture, the State can lower the water quality classification for allowable pollutant loading from wastewater dischargers. An example of this was the change in water quality standards in 1999 for ammonia discharge to Landis Creek in Spring Valley. Significant development was proposed and subsequently approved, but the flow in Landis Creek is small and applicable ammonia standards for the wastewater discharge were very difficult to meet under the previous standard. The State classification was changed from Cold Water Aquatic Life Class 1 to Class 2, with an associated change in un-ionized ammonia standard from 0.02 mg/l to 0.1 mg/l. While this standard change would not be appropriate for the Roaring Fork and key tributaries where there is an established cold-water fishery, this issue demonstrates that development will have conflicts with high quality stream standards. Conversely, in the water quality classification review of 1999, it was determined that fisheries and portions of the habitat in Brush Creek through Snowmass Village had improved over time, and the state classification of Brush Creek was upgraded from Cold Water Aquatic Life Class 2 to Class 1. The key is for communities to work together to implement consistent programs for watershed protection, and exercise the political will to ensure that all citizens are doing their part to maintain water quality. Improving stormwater management practices is an important step in protecting and enhancing water quality conditions.

1.4 Evolution of Stormwater Regulations

In 1972, Congress passed what is currently referred to as the **Clean Water Act** (CWA). The Act established the **National Pollutant Discharge Elimination System** (NPDES) program. Until recently, efforts under the NPDES program have focused on non-stormwater discharges from industries and municipal wastewater treatment plants. In the last several years, the EPA has expanded the NPDES program to cover municipal stormwater discharges.

Phase I Stormwater Regulations

The CWA placed controls on non-stormwater point discharges, but it has become evident that diffuse sources such as stormwater runoff can significantly impact water quality. In 1987, the CWA was revised to include stormwater discharges. The CWA defined municipal and industrial stormwater runoff discharges at end of pipe as “point source” and called for a two-phase permitting strategy. Phase I affected municipalities with populations over 100,000. These municipal discharges included the Colorado cities of Denver, Lakewood, Aurora, Colorado Springs and the Colorado Department of Transportation. These five entities have made great progress in instituting stormwater controls. Regulation of municipal stormwater discharge permittees (*Municipally Separate Storm Sewer System* or “**MS4**”) requires that certain programs be in place. These programs are:

1. Commercial/Residential Management Program. This program includes application and maintenance of structural stormwater controls, and evaluation of permanent water quality facilities.

2. “Illicit Discharge” Management Program to separate stormwater and sanitary sewer discharges. This program generally includes the prevention of illicit discharges and illegal disposal, and educational activities to promote public reporting of illicit discharges and improper disposal of toxic materials.

3. Industrial Facilities Program. The purpose of this program is to have municipalities control industrial stormwater discharges into their local stream system.

4. Construction Sites Program. This program involves ensuring that adequate measures are taken to control runoff from construction sites **1 acre** and larger that pose water quality concerns.

5. Municipal Facility Runoff Control Program. This program requires that measures comparable to those required for industrial activities be implemented at municipal facilities.

6. Wet Weather Monitoring Program. The purpose of this program is to monitor trends in water quality that may be the result of stormwater runoff.

Phase II Stormwater Regulations

The Phase I program excluded municipalities with a population under 100,000, termed ***Small Municipal Exemption***. When the amendment to CWA was passed in 1987, the intent under the stormwater program was to require smaller MS4’s to apply for an NPDES permit no later than October 1992. This date was later changed to October 1, 1994, and now to **March 10, 2003** for all Phase II cities.

On January 9, 1998, the EPA published draft rules for the Phase II program. These draft regulations include many more municipalities and construction sites by:

1. Reducing construction site size from 5 acres to 1 acre for developments required to obtain an NPDES stormwater permit.

2. Expansion of the MS4 permits to automatically include communities with populations between 50,000 and 100,000.

The State must evaluate communities for inclusion into the Phase II program if they have a population between 10,000 and 50,000, are outside an urbanized area, and have a population density of 1,000 people per square mile or greater. Evaluations were made based upon the following five criteria:

1. Discharges to "sensitive" waters,
2. High growth or growth potential,
3. Size of population and population density,
4. Contiguity to an urbanized area, or
5. Significant contributor of pollutants to State waters.

For Colorado, this means that approximately fifty additional communities could fall under this program. Most of these are on the Front Range; however, a few West Slope communities are included. Based upon their populations, Grand Junction and Mesa County have automatically been included in the Phase II program. Durango was evaluated for inclusion in the program. **Glenwood Springs**, Palisade, Fruita, Montrose, Cortez, Craig and Steamboat Springs could be designated for inclusion in the Phase II program. Based upon the bed count, the towns of Aspen and Snowmass Village may also eventually be included in the program. The regulation proposes covering these Phase II communities under a *General* permit rather than *Individual* permits.

Although Glenwood Springs is not a Phase II community, this report has been designed and formatted to prepare the City for eventual inclusion in the NPDES program.

1.5 Six Minimum Control Measures

This report organizes recommendations for stormwater management in Glenwood Springs into the six categories identified in the national NPDES program (see tabs). The proposed programs that will be required in the Phase II *General Permit* include the following six categories:

1. Public Education and Outreach on Stormwater Impacts. This requires the distribution of educational materials to the public or other equivalent outreach efforts.

2. Public Involvement/Participation. This element involves public notification and inclusion of the public in the development and implementation of the municipalities' stormwater management program.

3. Illicit Discharge Detection and Elimination. This involves some identification of pollutant sources, and the control and detection of illicit discharges.

4. Construction Site Program. This requires the development, implementation, and enforcement of a program for controlling runoff from construction sites that are equal to or greater than one acre.

5. Post-Construction Stormwater Management. This requires new development and redevelopment to implement permanent stormwater controls. Ordinances require implementation of a program to address stormwater runoff from development and redevelopment sites equal to or greater than one acre.

6. Pollution Prevention/Good Housekeeping for Municipal Operations. As proposed, this involves the development and implementation of an operation and maintenance program to reduce the pollutant runoff from municipal sites such as parks and open spaces, fleet maintenance facilities, building oversight, and stormwater system maintenance facilities.

1.6 Guiding Principals

This report was developed as a first step to implementing programs that help protect the water quality of the rivers. Guiding principals of this document are:

- Protect receiving water bodies from water quality degradation.
- Maintain and implement water quality standards that preserve the rivers as irreplaceable resources of the Valley.
- Protect the public health and safety by preserving safe drinking water supplies, and minimizing pollutant loading to aquatic ecosystems and recreation areas.
- Develop technically feasible, maintainable drainage solutions that are acceptable to the community.

1.7 Goals and Objectives

This project's major goals are to:

1. Identify, describe and evaluate stormwater runoff sources, runoff quantity, and water quality composition,
2. Assess the programs and ordinances in place to manage stormwater runoff,
3. Recommend appropriate "Best Management Practices" for stormwater,
4. Develop non-point source pollution education materials and activities to achieve greater awareness of the impacts of stormwater runoff, the importance of water quality to healthy river ecosystems and recommended volunteering approaches for reducing erosion and pollutants in runoff.

This report evaluates and describes the existing stormwater runoff conditions in City of Glenwood Springs, focusing on existing outfalls into the rivers. This project evaluated stormwater runoff within the City of Glenwood Springs primarily for the purposes of evaluating water quality, and identified Best Management Practices (BMP's) and recommendations for implementation. The first phase included a physical examination of the Glenwood Springs stormwater infrastructure. The second phase included recommendations for improved stormwater management and water quality sampling of stormwater runoff.

2. AREA DESCRIPTION

2.1 Drainage Basin Characteristics

The Roaring Fork River is a major tributary to the Colorado River. The headwaters of the Roaring Fork River start above 14,000 feet elevation at Independence Pass near the City of Aspen and continue approximately 60 miles downstream to the confluence at the City of Glenwood Springs at elevation 5,700 feet. At the confluence with the Colorado River, the Roaring Fork River has a 1,460 square mile drainage basin.

2.2 Climate

Historical Precipitation Data

The Glenwood Springs Weather Station has recorded temperature and precipitation data since 1900. The average annual precipitation is 16.7 inches, with half (8.3 inches) occurring in the winter months November through April. The average annual snowfall in Glenwood Springs is 55 inches. Table 1 summarizes the average annual precipitation data for the Glenwood Springs on a monthly basis.

TABLE 1
GLENWOOD SPRINGS
MEAN MONTHLY PRECIPITATION
(All Values in Inches)

Region: **Glenwood**
Period of Record: **1900-2000**
Gage Elevation (feet): **5,900**

	TOTAL PRECIPITATION	SNOWFALL
January	1.50	16.4
February	1.30	10.9
March	1.44	6.1
April	1.64	1.7
May	1.43	0.3
June	1.14	
July	1.28	
August	1.51	
September	1.55	
October	1.46	1.1
November	1.14	4.9
December	1.30	13.5
Annual	16.69	55.0

Flooding events in Glenwood Springs usually begin with summer thunderstorms of short duration and very high intensity. Runoff from snowmelt and from long-duration rainstorms seldom produces a large enough discharge to create mud and debris flow problems within the City. The intensity of rainfall is more important in generating damaging floods than is either the total duration of rainfall or the total quantity of rain.

Hydrologic Data for Stormwater Runoff

Data on precipitation from the "National Oceanic and Atmospheric Administration's Atlas 2, Volume III" - Colorado, dated 1973, indicate that in the Glenwood Springs area, a 24-hour storm would produce the following precipitation for different storm recurrence intervals:

Storm Event	24-Hour Precipitation (inches)
2 - Year	1.18
5 - Year	1.54
10 - Year	1.72
25 - Year	2.12
50 - Year	2.32
100 - Year	2.52

2.3 Base Mapping

The following maps were used in this study:

1. City Topographic Mapping - Topographic mapping flown April 15, 2001 and produced with 2-foot contour intervals was available for the City Limits with a surrounding buffer area.
2. USGS Topographic Mapping - USGS 40-foot contour interval topographic mapping was available for the entire area and upper drainage basins. The coarse mapping was used to delineate drainage basins for the hillsides above the City.
3. Aerial Photography – Rectified aerial imagery was obtained from the City from the April 15, 2001 flight.

2.4 Surface Geology Impacting Runoff and Erosion

The local surface geologic conditions cause heavy rainstorm events at Glenwood Springs to manifest into large debris flows and mud floods. The red- and gray-colored mountain slopes which ring the city consist of sedimentary rock formations whose weathering products are unusually susceptible to debris flow activity. Although a number of different formations outcrop in and near Glenwood, the most important rock units are the *Eagle Valley Evaporite* and the *Maroon Formation*. The Eagle Valley Evaporite is the soft, grayish-colored rock forming the lower slopes of the valley walls, and the Maroon Formation is the group of reddish rocks occurring higher on the slopes. The contact between the two formations dips (slopes downward) to the south. Consequently, the Eagle Valley Evaporite is prominently exposed in the northern part of town, near the Colorado River, but is almost completely buried underground in the southern part of the city.

Eagle Valley Evaporite

The Eagle Valley Evaporite is a thick body of impure gypsum, calcareous sandstone, dark shale, halite, and anhydrite, the last two of which do not occur near the ground surface. This formation developed during Pennsylvanian time from the precipitated minerals and fine-grained sediments that accumulated at the bottom of a shallow, very salty sea. Since the water-soluble minerals which make up much of the Evaporite tend to deform plastically when loaded over very long time periods, the weight of the mountains has caused the formation to "flow" out from under the high ground and to well up under the Roaring Fork Valley. As a result, a very thick mass of contorted, deformed Eagle Valley Evaporite underlies Glenwood Springs. Where exposed, the rock is gray, gray-black, or yellowish gray. It weathers to form fine-grained, low-density, porous soils with cemented structure. Within the gulches and on the lower hillsides at Glenwood Springs, the Evaporite forms prominent stacks (pinnacles of relatively-intact rock), which rise above the slopes of soil and weathered rock. Both the outcrops and the loose boulders usually have low densities and appear to be partially decomposed because the water-soluble minerals leach out upon exposure to the elements.

Soils formed from the Eagle Valley Evaporite absorb water easily and change to thick slurries that resemble wet, dirty *Plaster of Paris* (to which the material is chemically related). During rainstorms, the uppermost few inches of soil on steep slopes actually begin to flow downhill in sheets. This slurry enters channels readily and constitutes a major source of debris during rainstorms. In addition, the Evaporite outcrops and soils are susceptible to rockfall, bank caving, and landsliding. Large debris flows derived from this material would be more likely to occur after a relatively wet period when the soils are saturated. Water drains very slowly from the fine-grained Evaporite material, and debris flows containing large amounts of this material tend to be relatively mobile and flow to considerable distances on debris fans.

Maroon Formation

The Maroon Formation is a thick sequence of red-colored sedimentary rocks that includes shale, siltstone, conglomerate, and thin limestone beds. It was deposited during Pennsylvanian and Permian time as a body of land and shallow-water sediments bordering the same sea in which the Eagle Valley Evaporite was formed. Upon weathering, Maroon rocks decompose to form accumulations of boulders, smaller rock fragments, and large percentages of sand, silt, and clayey silt. The inherent strength of the intact rock causes it to form steep slopes and cliffs, while the inherent weakness of the soil and weathered rock forms extensive, marginally stable slopes of talus and colluvial debris. Although most of the Maroon-derived soil and weathered rock is of comparatively recent origin, similar but much-older deposits exist as patches at various points on the mountainsides. These old deposits apparently represent debris flow, mud flood, earth flow, and landslide detritus that may be as much as one or two million years old.

Upon sudden wetting and saturation, segments of the Maroon-derived slope deposits fail abruptly as debris avalanches. The debris avalanches then either enter the gulches directly or mix with water and become small debris flows as they move down the hillsides and into the channels. Additionally, the same material may fail by bank caving and by shallow, translational landsliding. On the basis of the mass-wasting processes involved, it appears likely that the largest debris flows involving Maroon Formation debris occur after relatively dry periods. Water can enter Maroon-derived soils readily when those soils lie on the slopes in a low-density state.

However, the debris contains enough fine particles to prevent the water from draining immediately from the flowing, saturated debris. Because of the susceptibility to both mass wasting and water entry, areas in which the Maroon Formation crops out on steep slopes are exceptionally prone to generate debris flows and mud floods throughout western Colorado.

Leadville Limestone

Geological formations in northern portions of Glenwood and West Glenwood are much different from those south of the Colorado River. The bedrock is usually the Leadville Limestone, a fairly competent sedimentary formation that does not produce the mix of fine- and coarse-grained debris conductive to the formation of mud floods and debris flows. Additionally, the Leadville Limestone is cavernous, and some fraction of the storm runoff over this layer finds its way underground.

3. FLOOD HISTORY

A problem for the City is the absence of a comprehensive, coordinated master planned stormwater drainage system and network. The original town site was laid out in an era when drainage facilities, in the modern sense, did not exist. The newer parts of town were developed in piecemeal fashion without specific regulation for drainage improvements. Glenwood's storm drainage infrastructure relies upon the steep grades to drain the city and include a few short, unconnected pieces of storm sewer, and the curb and gutter lining the street. One of the major drainage structures in the City is the Twelfth Street Ditch.

Although the drainage systems and historic irrigation ditches are capable of handling runoff from ordinary storms, larger downpours create flooding, erosion, and sedimentation problems throughout most of the city. This leads to much nuisance flooding during thunderstorm runoff and, in some areas, causes significant problems. Examples of such problems identified in the 1982 Drainage and Debris Control Plan include:

- General flooding of streets, yards, and basements in the older parts of downtown, generally defined by Eighth Street, Eleventh Street, Garfield Avenue, and Blake Avenue;
- Occasional flooding of the same part of town by overflow from the Twelfth Street Ditch;
- Flooding on Hyland Park Drive near Grand Avenue and lower debris fans, caused by storm runoff in the natural basins from the above hillsides;
- Water flooding in the vicinity of Grand Avenue between its intersection with Glen Avenue and the Sunlight Bridge, caused by the concentration of storm runoff from the upper hillside basins at the few points where that runoff can cross Glen Avenue and the former Denver & Rio Grande Western Railroad; and
- Local flooding problems on a number of other small watersheds throughout the area, often associated with blockage of irrigation ditches by debris flows.

3.1 Mud and Debris Flows

Debris flows and mud floods are extremely common in the Glenwood Springs area. In fact, they appear to be the dominant form of flood event for most of the smaller watersheds of the region. Small intermittent and ephemeral streams that produce continuous water discharges only during spring runoff and after major storms drain most of the small basins tributary to the Colorado and Roaring Fork Rivers. With a few exceptions, such as Cemetery Gulch and the gulches draining Red Mountain, Oasis Creek and Mitchell Creek, the mountainside gulches surrounding Glenwood Springs fall into the ephemeral stream category; that is, they carry water only in response to a storm. This means that there is no base flow capable of shaping a stream channel. Consequently, the gulches are adjusted to a flow regime dominated by flash floods of varying magnitudes and types.

Most of the City is built upon the broad slopes that descend from the mountainsides down to the valley bottoms. These slopes, which appear ideal for human occupancy to the casual observer, are actually debris fans – cones of soil and rock washed down by debris flows and floods acting over the long periods of geologic time. The geologic processes that created the fans are still active today, and people living on the fans must expect periodic debris flows and floods, unless significant drainage infrastructure is constructed and maintained.

Growth into these hazard areas carried with it an extra price tag, which is usually not fully realized until a flood event. This fact was brought home July 24, 1977. It was on that afternoon that an unusually sharp thunderstorm spawned debris flows – torrents of water, mud, rock, and tree limbs – that swept out of the steep, mountainside gulches and inundated nearly 200 acres of the city. The event was repeated on a smaller scale in 1981, and convincingly demonstrated that much of Glenwood Springs was subject to severe flooding hazards due to debris flows and lesser flash floods. Faced with the property damage, the cleanup costs, the loss of personal possessions, the lost time, and the general inconvenience, citizens of the community reacted with dismay.

All told, the debris flows of 1977 and 1981 produced well over $500,000 in documentable damages and cleanup costs. Even disregarding the uncounted hours of work put in by individuals, loss of property values, and other undocumented costs, this is a great deal of money for a town the size of Glenwood Springs. More significant, however, is the fact that more, and bigger, debris flows are likely to occur. The 1977 debris flow was assumed to be approximately equivalent to a 25-year event, and the 1981 flow was assumed to approximate a 10-year event. Future flows will undoubtedly cause losses at least as great as those already experienced without additional drainage infrastructure to handle the flooding. Although the newly developed parts of town are among the areas subject to the most serious risk, many of the older districts share the same hazard. Most of the high-hazard zones include residential neighborhoods and thus subject a large percentage of the population to the risks of damage and injury.

3.2 History of Flooding

The records of flooding for Glenwood Springs are incomplete. Most flood information comes from either old newspaper files or National Weather Service publications, and these usually only mention flooding on debris fans if it affected a populated area or was otherwise of unusual interest. Since so much of what is now Glenwood Springs was open ranchland, there are few formal records of flood events on fans outside the limits of the original town site. Nevertheless, it is clear from the available information that at least 18 significant episodes of flooding have occurred on the fans in and near Glenwood Springs since the turn of the century. There has been an average of more than one debris flow or mud flood of major magnitude in every five years. Mud and debris flows have occurred so regularly in Glenwood Springs that residents have learned to accept these natural hazards as a fact of life. Periodic rains carry mud onto roads and driveways and residents and city staff must periodically clean up after this nuisance. However, extreme events can be very damaging and pose a risk to safety and property.

One of the first recorded flooding events occurred just south of Glenwood Springs in 1903. A newspaper items noted that a rainstorm had caused mud and rock to cover one of the railroad lines resulting in a wreck that killed a member of the train crew. The next report dates from 1917 and reports a flood that apparently occurred in Basin E-1, the northeastern part of Glenwood Springs. The Glenwood Springs area again suffered damage during a series of storms that affected most of the central Colorado Rockies between July 27 and July 30, 1929; similar storms caused damage at various locations surrounding the city on July 28, 1933, early August 1933, and September 3, 1934.

The major debris flow and mud flood events within the original town site date from the late Thirties and early Forties. A storm on July 10, 1936, blocked the highway in Glenwood Canyon at six places. This was a prelude to a large mud flood within the city itself on September 1, 1936. Although flooding was widespread on the east side of the Roaring Fork Valley, most of the reported damage resulted from flooding on Cemetery Gulch (Basin E-3) and the many small drainages of Basin E-2. Following this storm, the City began discussions with the Works Progress Administration (WPA) concerning the building of a flood control ditch along Twelfth Street, below Cemetery Gulch.

No progress had been made on the ditch by July 30, 1937, when another sharp thunderstorm struck the slopes of Lookout Mountain. The storm, which lasted about half an hour and yielded about 0.70 inches of rain, came only two days after a rainstorm that dropped about 1.80 inches of rain. This time, very large debris flows came down Cemetery Gulch to inundate much of the town site. Newspaper reports describe mud deposits nearly two feet thick at the corner of Twelfth Street and Grand Avenue as well as major damage to railroad property near the depot at Seventh Street and Blake Avenue. Older residents report that boulders up to two feet in diameter were strewn about near the intersection of Ninth Street and Grand Avenue. This disaster prompted construction of the Twelfth Street Ditch by the WPA during the following summer. On August 13, 1938, the partly completed ditch safely conveyed a flood (probably a low-concentration mud flood) to the Roaring Fork River.

Another major debris flow occurred on July 30, 1943 within the original town site. Cemetery Gulch was again the primary basin involved. The inlet to the Twelfth Street Ditch apparently became blocked early in the flood, and most of the debris flow jumped the channel to spread northward into the older part of town. The railroad again sustained serious damage, and debris accumulated in the streets to depths of several feet. Considerable damage within the business district also occurred as a consequence of secondary water flooding.

The 1943 event was the last severe debris flow or mud flood to have a major impact on the built-up parts of Glenwood Springs prior to 1977. Flooding occurred in what is now the south end of town in the summer of 1947. This area was then undeveloped, and it is unlikely that damage was sufficient to merit notice in the newspaper. The next event to merit formal recording was on August 31, 1963, when a brief thunderstorm produced flows in Basins E-1 and E-2. Unconfirmed recollections of flooding in the south Glenwood Springs area during the early Sixties refer to a southward extension of this same flood.

With the expansion of the urban area into West Glenwood, reports of debris flows and mud floods in that sector become more frequent. A series of small debris flows and rockfalls closed U.S. Highways 6 and 24 in the canyon west of Mitchell Creek on July 16, 1967. Small debris flows in West Glenwood occurred on June 10, 1970, in June of 1972, and again on July 15, 1975. Most of these events affected the suburban residential neighborhoods north of Donegan

Road or the Highway (now Interstate 70) west of Mitchell Creek. These events, which were relatively small, dominated the public's perception of flooding hazards prior to 1977.

The 1977 floods took place on the afternoon and evening of July 24, following a period of prolonged drought. A brief, but very intense, thunderstorm generated debris flows and mud floods in many of the watershed's drainageways onto the southern two-thirds of the city. Flooding affected nearly 200 acres within the town, leaving mud and debris deposits up to four feet thick near the fanheads and sheets of silty mud two to four inches thick between Grand and Glen Avenues and the Roaring Fork River. Most of the damage was sustained on the debris fans of Basins E-6, E-10, E-12, and E-13. Large flows also occurred on the west side of the valley, particularly in Basin W-12, but the low density of development of those fans minimized the monetary damage. It is interesting to note, given the fire damage in 2002, that the uppermost parts of the E-12 watershed were burned over in a brush fire in late 1976, an event that might have contributed to the severity of the 1977 event.

An event that occurred on July 12, 1981 was in many respects a smaller version of the 1977 debris flows. Of the approximately $100,000 in damages, most was attributable to Basin E-10; the hardest hit basin in 1977. As in 1977, the floods occurred after an unusually dry winter and spring. Smaller debris flows, mud floods, and water floods followed throughout the summer, although none achieved the magnitude of the July 12 event. The primary importance of the 1981 floods was not in the damage incurred, but in the fact that the citizens of Glenwood Springs became aware that debris and mud flooding was a fact of life in the city. A ***Drainage and Debris Control Plan*** was prepared in 1982 by ESA Geotechnical Consultants and ARIX, and was a direct outgrowth of the public concern raised by the storms of 1981.

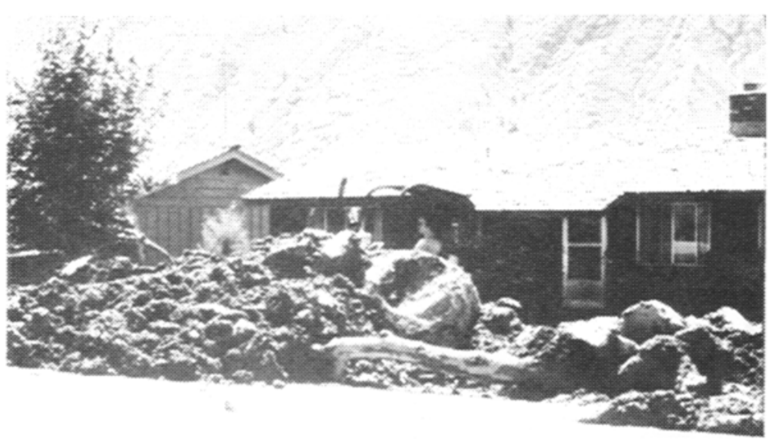
3.3 Impact of Fires on Flooding

Glenwood Springs has a history of wildfires causing major damage and affecting the entire community, which has become evident in recent years. Fires burn the vegetation on the mountainside leaving large areas of unstable and highly erodible soils. During spring runoff, flows wash mud and fire debris down the mountainside causing massive mudslides. Mitchell Creek recently experienced such flooding as a result of two wildfires. The drainageway is lined with residential properties and drains Subbasin N-1. The Storm King Fire in 1994 and the Coal Seam Fire in 2002 both burned portions of the hillside in Basin N-1 resulting in mud flows in Mitchell Creek.

Looking down 2100 Block Bennett

Lincolnwood Subdivision

1977



Collinson's 2100 Block Bennett

1981

Mud flood!

A TWN* Staff Report

GLENWOOD SPRINGS — The city of Glenwood Springs was digging out Tuesday from one of the worst natural disasters in the city's history — caused by rampaging mud flows that left an estimated $2 million in damages and expenses in their sloppy wake.

The mud flows, which rumbled like rivers down normally dry gulches on the sides of Lookout and Red Mountains Sunday evening, were set off by heavy rains which dumped about one inch of rain in less than an hour. Nearly two inches fell in the area during the day.

No one was injured.

Damage, however, was widespread, and severe in two locations in south Glenwood Springs, where mud, rocks, trees and other debris crashed through basement windows and garage doors, covering floors with as much as five feet of residue.

City police reported some problems with "gawkers" in the damaged areas, but there were no reports of looting, even though some families were forced to leave their houses during the height of the battering.

Cleanup operations began immediately after the storm hit early Sunday evening, and most roads — some of which were covered by several feet of debris — had been opened by early Monday morning. It would be several days, even weeks, before restoration of some houses would be complete.

The rivers of mud — three of them east of the Roaring Fork River, two smaller ones on the west bank — began rumbling down the gullies between 5:30 and 6 p.m., near the end of a lashing, thunder-filled storm that equalled the intensity of a tropical downpour.

As the rain lessened, several residents who live high on the skirts of Lookout Mountain in southeast Glenwood began hearing rumbling noises.

Sheriff Ed Hogue, looking up the mountain from his residence near the river, saw a huge wall of mud, flowing down the red dirt mountainside like lava from a volcano. It carried immense boulders and lifted massive trees out of the ground.

In the house of Grace and Larry Schick in the 21-hundred block of Bennett Ave., 15-year-old Debbie Schick looked out her back window and saw another wall of mud, almost on top of the house.

She began screaming to her brother Bill, 17, who was in the family's basement with a friend, Craig Stout. They grabbed their dog and several newborn puppies and ran into the street where neighbors, some of whom had heard Debbie Schick's screams, were trying to move cars out of the path of the fast-moving mud flow.

Bill Schick moved one of his family's cars, but within minutes the mud had lifted one car and deposited it across the street, floorboard deep in mud, on the front doorstep of Glenwood Post Publisher Tom Collinson.

The block between 21st and 22nd on Bennett was the heaviest hit, but damage did not stop there.

It filled up an 8-foot-deep sunken patio. It broke garden-level windows and poured inexorably into basements, sucking up books, records, toys and other belongings, destroying washers, dryers, pool tables, furniture and carpeting and drapes.

It lifted a food-filled freezer from the garage of school superintendant Nick Massaro at 26th and Blake and moved it into the front yard. It ruined scores of lawns, buried driveways, twisted patio furniture and buried swing sets.

Most houses were not covered by insurance for mud or flood damage.

When it reached storm drains, the oozing mud invaded the city's sewer system, eventually plugging up the 63,000 gallon primary sewage clarifier

[see page 3]

Mud flood: 'like a freight train'

[continued from page 1]
with tons of silt, forcing the city to bypass its treatment system and dump raw sewage into the Roaring Fork river until sweating crews of shovelers and bucket brigades could clean the huge tank and get it working again late Monday.

All in all, City Manager John West estimated, the storm caused about $2 million in damage in Glenwood Springs.

But damage did not stop in Glenwood, despite lesser amounts of rainfall in surrounding areas. At Mid-Continent Coal & Coke's Redstone mine, mud and boulders smashed through structures, causing extensive damage.

Mid-Continent vice president Robert Delaney said the company's bathhouse and district office building were destroyed by boulders rolling near the confluence of Dutch Creek and Coal Creek. The flooding also washed out parts of the road linking the mine facilities with Highway 133.

Damage, Delaney said, probably would be in excess of $100,000.

Other mud and rock slides were reported on McClure Pass south of Redstone, in Glenwood Canyon, and on smaller county and private roads through the area.

But the greatest damage came in Glenwood Springs, where many residents, policemen and other city employees worked throughout the night Sunday and early Monday, scraping up the tons of debris.

The most severe damage was caused in the block between 21st and 22nd on Bennett Ave. to homes owned by Jerry Fiegel, Clark Millison, Julius Voight, Collinson, and Schick; at 21st and Blake to the home owned by Bill Sisson, and at 26th and Blake to the home owned by Massaro.

"It sounded like a blooming freight train coming down the hill," Fiegel said Monday. When he heard it, he said, he looked out the window to see a wall of mud, pushing rocks ahead of it. He and his wife had time only to get their cars out of the garden-level garage before the flow hit their house.

It piled up three and four feet deep at the front door, broke basement windows, and deposited about four feet in the basement. By Monday afternoon, Fiegel had counted 100 wheelbarrow loads from his basement alone.

GLENWOOD POLICE CHIEF Bob Halbert points out flood damage Monday afternoon to Gov. Richard Lamm.

The force of the mud was so intense that huge boulders, some as large as four feet in diameter, were pushed along like marbles, until they came to rest against something more substantial.

The pressure of the tons of mud built up against the back of Schick's house at first led to fears that the foundation of the $70,000 house had been cracked. After crews began scraping the mud from the ruined basement level, however, it appeared that the foundation had remained in place.

The basement, however, was five feet deep in rocks and mud. Books floated in the ooze. New furniture was crushed under rocks.

Behind Fiegel's house, one block down the hill on Blake Street, Sisson was up most of the night trying to build makeshift dikes at the rear of his house — which he moved into three weeks ago — to stop the mud.

He could do nothing about protecting his yard. What once was an eight-foot sunken patio was turned into an even layer of mud, with a floating planter filled with untouched pansies sticking up above the slime.

As the individual homeowners battled into the night to protect their homes, yards and possessions, city crews began cleaning streets, some of which were several feet deep in mud and rocks.

In one of the worst rock slide areas, boulders bigger than four feet in diameter blocked the intersections of Palmer and Blake on 26th St., not far from Massaro's house, which also received a basement full of mud, along with other damage to vehicles and appliances.

Several houses on Blake Ave., north of Massaro's house — one car was up to its door-handles in a mud-filled garage — suffered moderate damage from the water and mud, and the Glen Valley Nursing Home at 23rd and Blake was left with big deposits of mud in yard areas.

The mud did not seriously damage the nursing home interior, however. One of the nursing home's employees, Kelly Applegate, said off-duty personnel were called in Sunday night and spent much of the evening blocking doors with blankets and mopping up the small amounts of mud that managed to get in.

As the cleanup continued, several residents were trying to determine when there had been a worse flood.

Lawrence "Bugo" Zancanella, one of the city's senior residents, remembered one mud slide in 1938 that "had this one beat all to hell." He recalled that it flowed mainly down 11th St., but covered an area between 7th St. and 13th St., from the top of the hill to the Roaring Fork River.

City officials, meanwhile, were waiting for word from state and federal governments to determine whether any of the damage would qualify for relief under disaster programs.

Gov. Dick Lamm, who was in Glenwood Monday for the ironic purpose of speaking about problems raised by the drought, toured the damaged areas with Police Chief Bob Halbert and Public Works Director Dick Cole.

Lamm said he would assign an assistant to check into the possibility of getting assistance from the Federal Disaster Assistance Administration.

Lamm, however, was not optimistic about the chances, saying that the federal classification of disaster usually comes only with large-scale disasters involving death and more extensive destruction.

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Glenwood Post

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Photo by Ross Dolan

his dog survey what is left of the landscaping urst Townhouses south of town. The posts of a fence. Despite the exterior devastation, the interior of Zerr's home fared quite well. Not so lucky was Nick Massaro just across the street. His yard was totally covered and his home sustained considerable damage.

Welcome rain turns vicious

By Peter Stauffer
Post managing editor

A Volkswagen was perched on its drive and appeared ready to break loose any minute. A river of mud and boulders was sweeping across the driveway, and the small automobile began to move a little with the tide. The Volkswagen seemed to teeter, but held its ground and was not washed away.

Sunday evening's downpour had started about 30 minutes earlier. The rain was beginning to slack off and people were emerging from their homes. At first, the sheets of water moving down the valley had seemed to be no threat, a welcomed break in the dry spell. But this rain was unlike other summer cloudbursts because when it stopped you could hear the water, mud and rocks rushing down the mountains above.

The Volkswagen belonged to Emmett Zerr, Jr., 1 Oakhurst So. Court. He and his wife had been unable to return to their home. They could not get across a river of debris that blocked the way to their dwelling, the first in the row of townhouses at Oakhurst.

Zerr had been spending much of his spare time working on a fence behind his home. Posts had been sunk in cement and he was ready to finish the job. His fence was wiped out. Lumber stacked nearby was scattered, rocks and mud piled up behind the house.

Before long, Zerr and his neighbors were at work with shovels. They started clearing away the red mud and rocks. Many who joined in appeared relieved. There had been no way of knowing how much mud would slide down the mountain and, now that it was over, most considered themselves lucky.

Others were not so lucky. Three blocks away, in the 2100 block of Bennett and Blake, basements had filled up with thick red mud. Yards were as much as four feet deep in mud and rocks.

Bill Sisson, 2102 Blake, stood in his front yard trying to hose away some of the mud. He said he had moved in three weeks ago. Now his back yard was deep in mud and it was seeping into his basement. Dinner, apparently interrupted, was cooking on the stove, but nobody was there to watch it.

On Bennett, a man with a bottle of wine in hand offered to conduct a tour through his flooded basement. From the outside, you could see that it was knee-deep in mud. He pointed toward his yard where records and papers were strewn about and said they were all a total loss.

Across the street, Tom Collinson, shovel in hand, waded through his yard. A neighbor's vehicle had come to rest just in front of his house and was half-submerged in mud. His garage door was smashed.

By 6:30, everybody was digging out.

"Take your shoes off," said one enthusiastic digger. "Hell, it's fun."

Another, who said he had only some flooding in his basement, shoveled away at a six-inch layer of mud. He counted himself among the fortunate.

"I'm luckier than hell," he said.

By then, city crews were arriving. They directed traffic and started clearing the streets. Firemen were checking for gas leaks.

On Grand Ave., there was little sign of what was going on a few blocks away, only a layer of mud on the street. A carhop at A&W Rootbeer Drive-in was taking orders as usual.

At Oakhurst, front-loaders soon arrived and began to clear away the rocks and mud. The street was littered with boulders, some as big as three or four feet across. Early this morning, trucks were still hauling away the loads of debris.

Thirty minutes of rain can make a lasting impression.

4. HYDROLOGY

This report summarizes the previous two known hydrologic studies encompassing the City of Glenwood Springs:

1. “Drainage and Debris Control Plan for the City of Glenwood Springs,” by ESA Geotechnical Consultants and ARIX, dated December 1982
2. “Flood Insurance Study (unpublished),” by the U.S. Army Corps of Engineers, dated December 1997.

The 1982 study pioneered delineation of the drainage basins and developed hydrology for the purposes of analyzing mud and debris flow through the City. The 1997 study was completed to map debris flow hazard areas, and built upon the 1982 study by using the same basin delineations and nomenclature. However, the hydrology was computed again by the Corps of Engineers, and the flows were generally lower than the calculated figures from 1982. None of the previous basin delineations were available electronically, and have been recreated in GIS for this study.

Since this study is focused on water quality, rather than peak flood flows, no new hydrological evaluations have been completed. The 1997 hydrology was determined to be closest to the actual values, and the results from that study have been reproduced here in Table 2. The 10-year and 25-year hydrology was not available in the 1997 study, and has simply been estimated based upon a ratio of the 100-year event flows.

The hydrology is shown for informational purposes only to assess the capacity of current infrastructure to convey stormwater runoff and delineate drainage basins. Design of stormwater systems will require a more detailed examination and modeling of hydrology.

It is also important to note that the hydrology is based upon vegetated hillsides. Wildfires can have a profound impact on hydrology, and can easily double, triple or even increase flows by 10 fold. Wildfires remove vegetation that absorbs rainfall, and can drastically reduce the infiltration capacity of the soils.

The following information is used to determine the hydrology for the City of Glenwood Springs:

1. Basin Delineations

Each of the drainage basins for the study is delineated on the foldout Drainage Basin Map and the attached 11x17 maps for City Basins. This shows the tributary area to each outfall. The name of each basin is shown on the top of the label circles. The basin size, in acres, is shown in the bottom half. Sub-basins are basins contained within the major basin delineations. Sub-basins provide hydrologic information at key locations within a basin, such as at a detention pond or storm drain inlet.

Major Basins

There are numerous drainage basins that capture and direct stormwater runoff and snowmelt throughout the City and ultimately into the Roaring Fork and Colorado Rivers.

These basins were originally delineated by ESA Geotechnical Consultants and ARIX in a 1982 "Drainage and Debris Control Plan." The basins were given labels 'E', 'W' or 'N' along with a number to identify basins east, west or north of the City. Hydrology was studied for the basins extending to the city limits, but not through the City. The U.S. Army Corps of Engineers in a 1997 Flood Insurance Study of hillside debris flow used these same basins and identification labels, but did not delineate basins through the City. This report began with the previously delineated basins and carried select basins through the City based upon the storm drain network, and specifically examined stormwater basins inside the City of Glenwood Springs.

Sub-Basins

The mapping shows well-defined runoff outfall points, covering most of the City's runoff area. These outfall points provide opportunities for monitoring during stormwater events. Detailed mapping of existing stormwater discharge points, their corresponding drainage areas, topographic relief, and land use practices is shown at the end of this report (see six fold-out 11x17 maps).

The Sub-Basins described above do not include every drainage basin within the City of Glenwood Springs, but are representative and significant for stormwater runoff. These basins represent the key areas for monitoring stormwater quality and quantity during runoff periods, and for addressing stormwater management practices.

2. Off-site Basins

Off-site basins are drainage basins feeding into the areas of interest. The hillsides above Glenwood Springs are "off-site" basins that contribute runoff water into the City.

3. Soil Types

Four soil groups, labeled "A" through "D", are used in determining hydrologic soil-cover complexes for estimating rainfall and snowmelt runoff as described below:

A. Low runoff potential. Soils have high infiltration rates, and are typically composed of sands and gravels.

B. Moderate runoff potential. Soils having moderate infiltration rates and consist chiefly of moderately fine to moderately coarse textures.

C. High runoff potential. Soils having slow infiltration rates and are typically fine grained or tight soils, such as clays.

D. Very high runoff potential. These are rock outcrops and tight clay soils.

The Soil Conservation Service (now "Natural Resource Conservation District") mapped the soil types around Glenwood Springs in May 1985 in a report titled, "Soil Survey of Rifle Area, Colorado." This information has been summarized through GIS mapping as it pertains to hydrologic grouping on the attached 11x17 fold-out map of the City. Soils within the Glenwood Springs Town Boundaries are generally Type B alluvial soils. Soils on the exposed hillsides are noted as rock outcropping with little infiltration. Soils on the upper peaks are shown as Type C and D soils.

4. Land Use

Land use is very import in determining the hydrology of a drainage basin and the type of pollutants that may occur in the stormwater runoff. As the imperviousness of a basin increases due to development (roofs, roads, driveways), runoff is more rapid. Land use classifications were used to determine the hydrology and recommendations for water quality sampling. The accompanying 11x17 map shows general land use by categories (residential, commercial, industrial) in the Glenwood Springs area.

Land use patterns are particularly important for the evaluation of stormwater runoff water quality and hydrology. By correlating drainage basins with land use, the potential pollutants from urban stormwater runoff can be predicted.

5. Stormwater Outfalls

Outfalls into the rivers were identified in the field and analyzed in this study. Significant and relevant outfalls are numbered 1 through 11 with yellow triangles and are described in this report as shown on the Glenwood Springs Stormwater Evaluation Plan map.

6. Discharges

Table 2 is a summary of the approximate peak discharge for each of the drainage basins during the 10-Year, 25-Year, and 100-Year storm events. A more precise Rational Method Hydrology Calculation should be computed for the drainage basins before design of infrastructure improvements.

TABLE 2
GLENWOOD SPRINGS HYDROLOGY

Basin	Map Area (Acres)	10-Year [1] Discharge (cfs)	25-Year [1] Discharge (cfs)	100-Year [2] Discharge (cfs)
E-1	122.0	82	120	190
E-2a	19.2	16	24	38
E-2b	10.2	9	13	21
E-2c	9.6	8	12	19
E-2d	2.6	3	4	6
E-2e	10.2	9	13	21
E-2f	3.2	3	4	7
E-2g	3.2	3	4	7
E-2h	5.1	5	7	11
E-2i	1.9	2	3	4
E-2j	1.9	2	3	4
E-3	251.0	155	227	360
E-5	20.0	17	25	40
E-6	35.8	30	44	70
E-7	111.0	67	98	155
E-10	89.6	62	91	145
E-12	115.0	77	113	180
E-13	115.0	75	110	175
E-15	20.5	17	25	40
E-16	15.4	13	19	30
E-17	11.5	11	16	25
W-10c	18.3	16	23	36.6
W-10d	19.2	17	24	38.4
W-11b	28.2	24	36	56.4
W-11d	7.0	6	9	14
W-11e	10.9	9	14	21.8
W-12	248.3	163	239	380
W-13a	63.4	51	74	118
W-13c	25.6	22	32	51.2
W-13e	10.2	9	13	20.4
W-14a	48.6	22	32	50
W-14d	27.5	35	51	81
W-15	69.1	43	64	101
W-16a	873.0	374	548	870
W-18	55.0	46	67	107
W-20	48.3	41	60	96
W-21	45.0	38	55	88
W-22a	35.8	30	44	70
W-22b	51.6	43	62	99
W-24	371.2	189	277	440
W-25a	25.3	22	32	50
N-1	7117.0	1505	2205	3500
N- 2	3.2	4	6	10
N- 4	9.6	9	13	20
N- 7	63.6	47	69	110
N- 9	493.0	194	284	450
N- 10a	100.0	60	88	140
N-11	80.0	54	79	125
N-12	468.0	161	236	375
N-13	1872.0	428	627	995
N-14	200.0	112	164	260
N-15	584.0	226	331	525
N-18	28.0	22	32	50

1. Approximate Estimated Values.
2. From USACE Flood Insurance Study, Hydrology, 1997

5. PHOTO INVENTORY

Field investigations for this report of the City's drainage infrastructure were made with City Staff on the following days:

July 16, 2002
October 4-6, 2002
October 19-20, 2002

The following pages of photographs highlight some findings and recommendations concluded during field investigations of the outfalls. The photo pages have been organized into the following seven categories:

1. Water Quality of Stormwater Runoff
2. Glenwood Springs Mud Flows
3. Stormwater Outfalls
4. Erosion Control Measures
5. Sedimentation Systems
6. Construction Site Erosion Control
7. Post-Construction Water Quality Systems

The following pictures are shown to emphasis that even the rural community of Glenwood Springs can have deficiencies in their stormwater systems, and there is opportunity for improvement of stormwater controls. These pictures represent a general overview of the City and point out issues, potential problem areas, existing stormwater systems, and make general recommendations for improvements in stormwater controls.

Water Quality of Stormwater Runoff

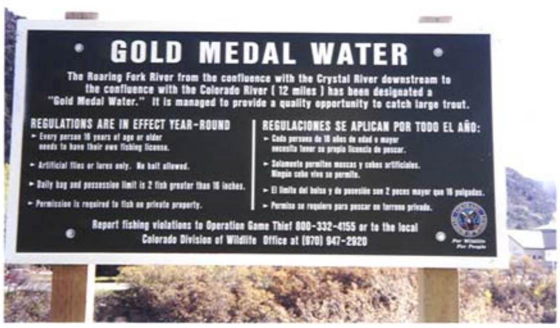

Figure 1: The Roaring Fork River through Glenwood Springs has been given the prestigious designation of "Gold Metal Water" signifying an excellent fishery. Degradation of water quality would undoubtedly change this classification.

Figure 2: Many citizens do not know that anything discharging into storm drains goes untreated directly into the river. This street inlet was improperly used to dispose of paint.

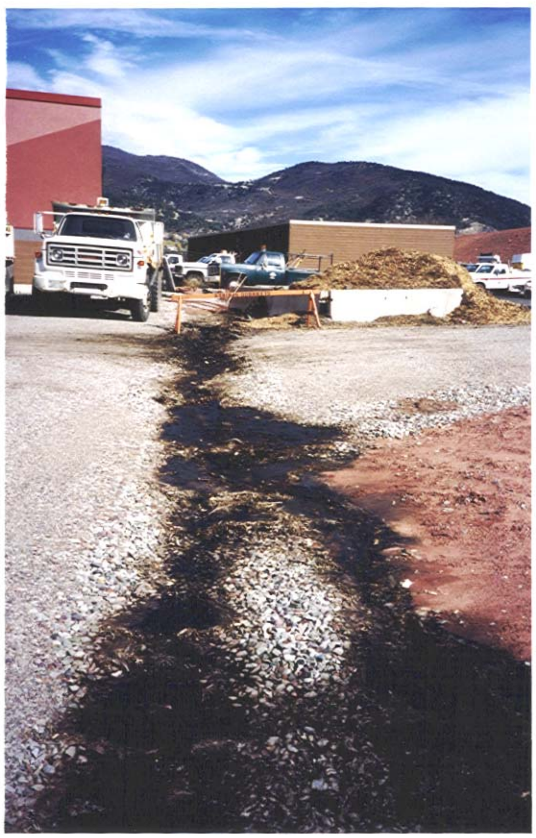

Figure 3: Stormwater mixing with pollutants can carry contaminants directly into the stream system. This is why Good Housekeeping principles and treatment of stormwater is so important in preserving the water quality in our streams.

Figure 4: Presently, oils and greases from this parking lot are carried by stormwater directly into the storm drain system, and then enter directly into the Roaring Fork River, untreated. Phase II stormwater regulations require communities to explore ways to treat stormwater runoff.

Glenwood Springs Mud Flows

Figure 5: The steep slopes around Glenwood Springs are highly susceptible to erosion from stormwater runoff, resulting in mud and debris flows into the City.

Figure 6: Development has occurred on historic debris fans making many structures vulnerable to flooding by runoff with water and mud.

Figure 7: This drainage gully located on Red Mountain has been preserved to convey mud and runoff to the river. Maintenance is needed on a regular basis to remove accumulated rock and dirt and provide adequate conveyance capacity.

Figure 8: Previous stormwater management programs attempted to direct mud flows to the rivers. Regulation of water quality has changed the approach to catching debris in upstream sedimentation basins.

Figure 9: This sedimentation pond, a multi-stage outlet in the Lincolnwood Subdivision, is designed to capture mud and debris and send cleaner runoff to the river, thereby improving water quality.

Figure 10: After the severe mud flows in 1977 and 1981, this homeowner constructed a berm to protect his property from damaging runoff.

Stormwater Outfalls

Figure 11: This 30-inch outlet to the Colorado River at the West Glenwood I-70 exit uses a flap gate to prevent river flooding from flowing into the pipe. The outfall is a potential water quality sampling point for highway runoff.

Figure 12: Many of the existing storm outfalls into the river shoot water onto the bank, eroding the hillside. Current designs usually incorporate a flared end section and riprap (rock) outfall to dissipate energy of runoff and prevent erosion at the outfall.

Figure 13: Regular maintenance is required to remove accumulated sediment. This pipe along the south bank of the Colorado River has carried sediment to the river after the recent fires left the hillsides exposed to erosion.

Figure 14: This outfall is properly constructed with a flared end section and riprap outfall.

Figure 15: This 24" CMP outfall from the new City Offices into the Colorado River is a potential sampling point for water quality from urban runoff.

Figure 16: This 48-inch RCP outfall directs runoff from the undeveloped hillsides in the north Glenwood area across I-70 and into the Colorado River.

Erosion Control Measures

Figure 17: This storm rundown near the Glenwood Municipal Operations Center along Midland Avenue is highly eroded. Improved erosion protection with grouted rock rundown will keep runoff from scouring sediment that often ends up in the river.

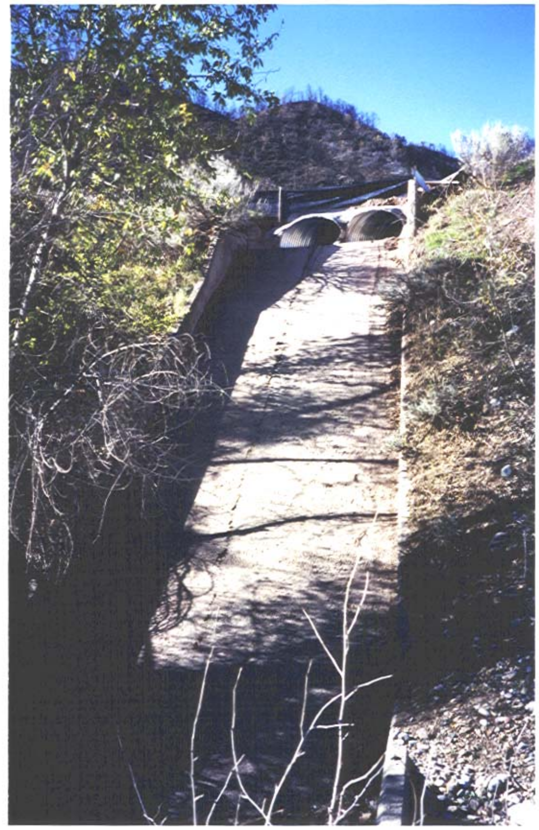

Figure 18: This steep rundown along the Railroad tracks in West Glenwood properly stabilizes the bank with concrete to prevent erosion.

Figure 19: Silt fences around construction sites are rarely constructed properly. This fence provides no water quality protection. Runoff will either flow under or over the filter fabric.

Figure 20: This silt fence is properly anchored and working efficiently to prevent sediment from flowing into the streets and storm drain system.

Sedimentation Systems

Figure 21: Mud flows from the hillsides currently flow into inlets and are conveyed directly to the rivers where they impact water quality and fill trout spawning beds. This mud flow from Red Mountain has created problems for residents and traffic on Midland Avenue.

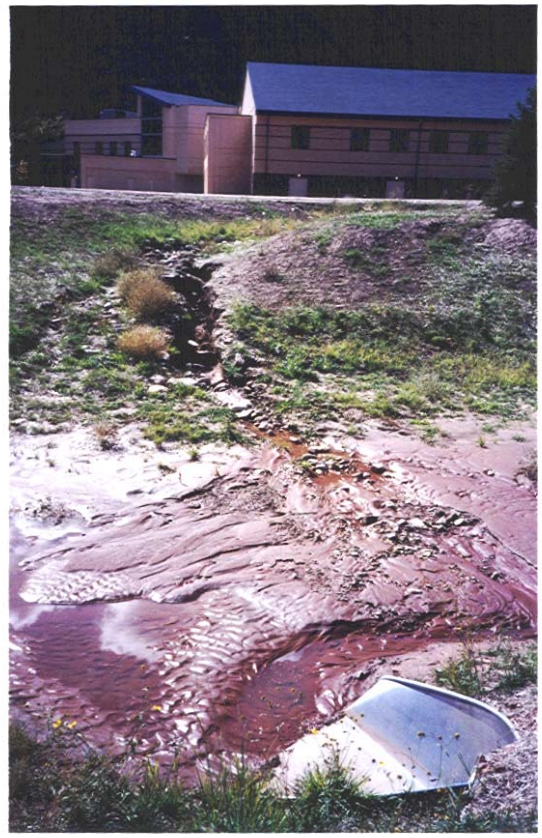

Figure 22: Sedimentation basins and detention ponds capture pollutants conveyed in stormwater runoff. This pond under construction at the new Community Center could be retro-fit with a water quality outlet to hold back sediment and other contaminants.

Figure 23: A huge effort was made to protect the Municipal Operations Center from mud flows by constructing this sedimentation basin. The 2002 fires have dramatically increased mud flows from the steep hillsides above the City.

Figure 24: This sedimentation basin behind the Municipal Operations Center protects the building from mud flows, but does little for water quality. The outlet should be retro-fit with a multi-stage outlet to keep sediment from leaving the pond.

Construction Site Erosion Control

Figure 25: These inlet protection devices are used during construction to keep mud from entering the storm drain system. Filter fabric usually covers the openings. However, as currently installed these devices are providing little water quality protection.

Figure 26: Construction sites can be the source of sediment that is carried into storm drains and discharged into the rivers. A "vehicle tracking pad" composed of washed gravel would act as a *floor mat* for vehicles and help to contain mud within this construction site.

Post-Construction Water Quality Systems

Figure 27: This water quality outlet near the Wastewater Treatment Plant is designed to hold back oils, grease and sediment collected from parking lot runoff. Regular maintenance is necessary to remove accumulated material.

Figure 28: This "dry well" in Cardiff Glen directs stormwater to a holding basin for percolation into the gravel. Maintenance is necessary to remove accumulated sediment. A major storm could overwhelm this system and back-up in the pipe or flow out the manhole cover.

Figure 29: This water quality outlet structure at Safeway informs citizens that anything dumped into the inlet will likely be conveyed directly to the Roaring Fork River. The NPDES stormwater program encourages installation of informational plaques such as this sign.

Figure 30: "Porous paving" is encouraged to promote infiltration of stormwater. These blocks can be used in parking lots to reduce the overall site imperviousness and reduce stormwater runoff.

Figure 31: An underground detention site is under construction in Glenwood at this development site. Underground systems are difficult to maintain. Surface storage sites are preferred methods of detention and water quality treatment.

Figure 32: This surface detention site around the new Sopris Elementary School is a good stormwater BMP. It collects runoff from the parking lot and directs it across grass areas to filter out sediment and other pollutants.

6. TASK #1: PUBLIC EDUCATION AND OUTREACH

There are six minimum control measures outlined by the NPDES program. The first task is *Public Education and Outreach*. This task is intended to meet the following objectives, and this report has provided valuable information to achieve these objectives:

OBJECTIVE	PROVIDED THIS REPORT
• Support for the project's educational component in the form of educational materials and maps	• Regional Map of Drainage Basins • Six City Maps of Drainage Facilities • Land Use Map • Soils Map
• Examples of recommended educational materials and outreach brochures	• Five tri-fold brochures provided by Colorado's Phase I communities and Urban Drainage & Flood Control District
• Descriptions of impacts of stormwater discharges on water bodies	• TABLE 3 – Urban Runoff Pollutants • TABLE 4 – Activities and Associated Pollutants • TABLE 5 – Comparison of Urban Runoff Versus Domestic Wastewater • TABLE 6 – Construction BMP's – Erosion Control • TABLE 7 – Comparative Pollutant Removal of Urban Runoff Quality Controls
• Description of steps that the public can take to reduce pollutants in stormwater runoff	• Five Tri-fold brochures produced by the Phase I communities (see appendix) – • Managing Your Construction Site, • Managing Your Household Wastes, • Caring for Your Lawn and Garden, • Pets and Water Pollution, and • Landscape Products & Water Pollution
• Discussion of improper waste disposal	• Text
• Description of impacts of illegal discharges	• Text
• Recommendations to form partnerships with other organizations	• Build upon materials developed by Phase I and Phase II communities

6.1 Potential Pollutants Based on Land Use

Urban stormwater runoff contains materials from various different land use types, such as residential, commercial and industrial sites. Urban stormwater runoff has been documented to contain a variety of constituents. When certain constituents are present in sufficient quantities, the potential exists for adverse effects on receiving waters. An 11x17 Land Use Map is available at the end of this report for identifying land use in Glenwood Springs for each drainage basin.

Impacts on receiving waters from urban stormwater pollutants can include:

- Sedimentation/Siltation from disturbed lands which affects fish spawning habitat and the macro-invertebrates that support the fish population
- Increased Biological Oxygen Demand (BOD) from organic pollutants which deplete the oxygen in the stream system
- Pathogens such as bacteria from waste which infect and kill aquatic life
- Toxicity such as oils, grease, metals and herbicides which kill aquatic life
- Nutrients from fertilizers and other pollutants which cause algae growth and other changes in species composition
- Temperature changes from surface runoff such as stormwater flowing over parking lots that alters the aquatic life

Studies such as the Nationwide Urban Runoff Program (EPA, 1983) and the Denver Regional Urban Runoff Program (DRCOG, 1983) have documented concentrations of various constituents in urban stormwater.

Table 3 summarizes the urban runoff pollutants, describes the sources of these pollutants, and lists the effects of the urban pollutants to receiving waterways such as the Roaring Fork and Colorado Rivers. Table 4 outlines various urban land uses and identifies associated typical pollutants found in stormwater runoff.

To understand the potential pollutant loading from urban stormwater runoff, the United States EPA under the Nationwide Urban Runoff Program (NURP) compared urban runoff water quality with raw sewage and treated sewage discharges. Surprisingly, urban runoff can contain a similar loading of total suspended solids and zinc, and an increased loading of lead, compared with raw sewage. Urban runoff can have a similar chemical oxygen demand as treated sewage, and more fecal coliform than treated sewage. Table 5 summarizes the comparison of urban runoff with domestic wastewater.

Table 3

Urban Runoff Pollutants

Constituents	Sources	Effects
Sediments – TSS, Turbidity, dissolved solids	Construction sites, urban/agricultural runoff, landfills, septic fields	Habitat changes, stream turbidity, recreation and aesthetic loss, contaminant transport, bank erosion
Nutrients – Nitrate, Nitrite, Ammonia, Organic Nitrogen, Phosphate, Total Phosphorus	Lawn/Agricultural runoff, landfills, septic fields, atmospheric deposition, erosion, carried within sediment loading	Algae blooms, Ammonia toxicity, Nitrate toxicity
Pathogens – Total and Fecal Coliforms, Fecal Streptococci Viruses, E. Coli, Enteroccus	Urban/Agricultural runoff, landfills, septic systems	Dissolved oxygen depletion, odors, fish kills
Organic Enrichment – BOD, COD, TOC and DO	Urban/Agricultural runoff, pesticides/herbicides, underground storage tanks, hazardous waste sites, landfills, illegal disposals, industrial discharges	Toxicity to humans and aquatic life, bioaccumulation in the foodchain
Salts – sodium chloride	Urban runoff, snowmelt	Contamination of drinking water, harmful to salt intolerant plants

Data Source: Handbook: Urban Runoff Pollution Prevention and Control Planning, 1993

Table 4
Activities and Associated Pollutants

Data Source: Handbook: Urban Runoff Pollution Prevention and Control Planning, 1993

Category	Nutrients	pH	Sediment	Organic Enrichment	Pathogens	Toxic Organics	Toxic Metals	Oil and Grease	Salts (TDS)	Hydrologic Alterations	Thermal Alterations	Pesticides
Agriculture												
Cropland	X		X									X
Pastureland	X		X	X	X							
Animal holding areas	X		X	X	X							
Animal waste storage	X		X	X	X							
Hayland	X		X	X	X							
Wash and processing water	X	X	X	X	X			X				X
Waste application areas	X		X	X	X		X					
Construction												
Highways, bridges, roads			X		X	X		X	X	X	X	
Land development			X		X			X		X	X	

Table 4, continued
Activities and Associated Pollutants

Data Source: Handbook: Urban Runoff Pollution Prevention and Control Planning, 1993

Category	Nutrients	pH	Sediment	Organic Enrichment	Pathogens	Toxic Organics	Toxic Metals	Oil and Grease	Salts (TDS)	Hydrologic Alterations	Thermal Alterations	Pesticides
Urban Land												
Stormwater sewers, combined sewers, surface runoff-pavement	X		X	X	X	X	X	X	X	X	X	X
Surface runoff-turf areas	X				X			X				
Infiltration walls and basins	X				X	X		X	X			
Land Disposal												
Wastes, sludge, septage	X	X	X	X	X	X	X	X	X			
Landfills	X	X	X	X	X	X	X	X	X	X	X	X
In-situ waste - water systems	X											
Hazardous waste areas	X	X			X	X	X	X	X			X

Table 4, continued
Activities and Associated Pollutants

Data Source: Handbook: Urban Runoff Pollution Prevention and Control Planning, 1993

Category	Nutrients	pH	Sediment	Organic Enrichment	Pathogens	Toxic Organics	Toxic Metals	Oil and Grease	Salts (TDS)	Hydrologic Alterations	Thermal Alterations	Pesticides
Hydrologic Modification												
Earthfills, channelization			X							X		
Dam construction/ reconstruction	X	X	X	X						X	X	
Other Sources												
Atmospheric deposition	X	X				X	X					
Underground storage tanks						X	X	X				X
Illegal disposal and dumping, release of contaminants	X	X	X	X	X	X	X	X	X			X
Highway/Bridge maintenance			X			X	X	X	X			X

Table 4, continued
Activities and Associated Pollutants

Data Source: Handbook: Urban Runoff Pollution Prevention and Control Planning, 1993

Category	Nutrients	pH	Sediment	Organic Enrichment	Pathogens	Toxic Organics	Toxic Metals	Oil and Grease	Salts (TDS)	Hydrologic Alterations	Thermal Alterations	Pesticides
Auto salvage						X	X	X				
Washing and processing area	X	X	X	X	X	X	X	X	X		X	X
Snow dumping areas	X		X	X	X	X	X	X	X			
Utility ROWs			X							X	X	X
Gasoline station						X	X	X				
In-place sediments	X	X	X	X	X	X	X	X	X	X		
Sewer leaks, domestic/wild birds and mammals	X			X	X							
Natural vegetation (leaves, fallen trees)	X		X	X	X							

Table 5
Comparison of Urban Runoff Versus Domestic Wastewater

Pollutant	Urban Runoff Concentration (mean, mg/L)	Raw Wastewater Concentration (mg/L)	Secondary Sewage Effluent Concentration (mg/L)
Chemical Oxygen Demand	75	500	80
Total Suspended Solids	150	220	20
Total Phosphorus	0.36	8	2
Total Nitrogen	2	40	30
Lead	0.18	0.10	0.05
Copper	0.05	0.22	0.03
Zinc	0.20	0.28	0.08
Fecal Coliform (Count/100 Mil)	Up to 50 x 10^3	Up to 1 x 10^8	200

Data Source: USEPA National Urban Runoff Program

6.2 Six Axioms for Treating Stormwater Runoff

Once the problems with urban runoff are understood, the community must be educated on ways to improve stormwater quality. To integrate an improved stormwater system into the City of Glenwood Springs, the following six axioms should be considered:

1. The most effective stormwater controls reduce both peak rate and volume by promoting infiltration through a reduction in impervious surfaces.
2. The next most effective controls reduce peak rates by temporarily storing runoff in detention ponds.
3. The design of water quality facilities should manage smaller, more frequent storm events. This is part of the "First Flush Doctrine" which states that most pollutants are carried in stormwater runoff by the first half-inch of runoff.
4. Encourage sediment deposition to the extent possible in stormwater runoff. Many pollutants have an affinity for sediments and are bound easily on the suspended sediment particles.
5. The most repugnant urban runoff pollutants are settleable. Nutrients and dissolved metals, however, may require other treatment.
6. Stormwater quality controls are in their infancy, which offers an opportunity to try new techniques.

6.3 Pollutant Removal Mechanisms

Planning urban stormwater controls requires matching the treatment method with the type of pollutants anticipated. A combination of appropriate pollutant removal or immobilization mechanisms should be used to treat stormwater runoff for water quality enhancement. The following is a brief overview of available proven mechanisms:

1. Sedimentation: Particulate matter is, in part, settled out of urban runoff. Sedimentation is the primary pollutant removal mechanism for most structural BMPs.
2. Filtering: Particulates are removed from water, in part, by filtration. Filtration removes particles by attachment to small-diameter collectors such as sand.
3. Infiltration: Pollutant loads in surface runoff are removed or reduced as surface runoff infiltrates or percolates into the ground. Particulates are removed at the ground surface by filtration, while soluble constituents can be adsorbed into the soil, at least in part, as the runoff percolates into the ground. Site-specific soil characteristics, such as permeability, cat ion exchange potential, and depth to groundwater or bedrock limit the number of sites where this mechanism can be used effectively.
4. Biological Uptake: Plants and microbes require soluble and dissolved constituents such as nutrients and minerals for growth. In addition, certain biological activities can reduce toxicity of some pollutants and/or possible adverse effects on higher aquatic species.
5. Straining: Grasses strain out particulates when sheet flow is directed to flow slowly over vegetated areas.

Given the above generally accepted approaches toward management of stormwater runoff, specific opportunities for improved management in the City of Glenwood Springs fall into five categories:

- Erosion control
- Improvement of stormwater conveyance
- Integration of detention facilities into land use planning
- Installation of water quality treatment controls
- Education of the community on management of stormwater runoff

Table 6 is a BMP planning tool for stormwater management. Table 7 compares the effectiveness of these stormwater controls for water quality treatment.

BMP Planning Section

Table 6

Construction BMP's - Erosion Control

BMP Planning For Construction

Surface Roughening	Mulching or Blankets	Revegetation	Roads and Soils Stockpiles

Construction BMP's - Sediment Control

Vehicle Tracking	Slope Diversion Dike	Roads and Roadslide Swale	Terracing	Slope Drain	Straw Bale Barrier	Silt Fence
Filter Strip	Sediment Basin	Waterway Crossing	Temporary Channel Diversion	Outlet Protection	Inlet Protection	

Structural BMPs

BMP Planning For New Development/ Redevelopment

Grass Buffer	Grass Swale	Modular Block Porous Pavement	Porous Pavement Detention	Porous Landscape Detention
Extended Detention Basin	Constructed Wetland Basin	Retention Pond	Constructed Wetland Channel	

Structural BMPs

BMP Planning For Industrial/ Commercial

Covering of Storage/ Handling Areas	Spill Containment & Control

Non-Structural BMPs

Good House-keeping	Preventative Maintenance	Spill Prevention And Response	Painting Operations Control	Above Ground Storage Tank Control	Loading and Unloading Control
Fuel Operations Control	Outside Material Storage Control	Vehicle and Equipment Washing Control	Wastes and Toxics Control	Pesticides, Herbicides, and Fertilizer Control	

Data Source: Urban Drainage & Flood Control District Criteria Manual, Volume 3

Table 7

Comparative Pollutant Removal of Urban Runoff Quality Controls

(Data Source: Schueler 1987).

BMP	SUSPENDED SEDIMENT	TOTAL PHOSPHORUS	TOTAL NITROGEN	OXYGEN DEMAND	TRACE METALS	BACTERIA	OVERALL REMOVAL CAPACITY
EXTENDED DETENTION POND	+	•	•	•	•	⃠	**MODERATE/HIGH**
WET POND	•	•	•	•	•	⃠	**MODERATE**
INFILTRATION TRENCH	+	•	•	•	•	•	**MODERATE**
INFILTRATION BASIN	+	•	•	•	•	•	**MODERATE**
POROUS PAVEMENT	+	•	•	•	•	•	**MODERATE**
WATER QUALITY INLET	O	⃠	⃠	⃠	⃠	⃠	**LOW**
FILTER STRIP	+	O	O	O	•	⃠	**LOW/MODERATE**
GRASSED SWALE	O	O	O	O	O	⃠	**LOW**

O- 0 – 20% Removal
•- 20 – 80% Removal
+- 80 – 100% Removal
⃠ Insufficient Knowledge

7. TASK #2: PUBLIC PARTICIPATION/INVOLVEMENT

Current Phase I communities and required Phase II communities have already made great progress developing materials for their own community stormwater management systems. This project presents materials developed by other communities for their Phase I and II programs. Contact was made with the Colorado Water Protection Project (CSU Extension), City & County of Denver, the Urban Drainage & Flood Control District and other communities to obtain previously developed educational materials and other valuable stormwater management information.

The goal of this *Control Measure* is to provide the following to communities:

- Advice on citizen forums
- Advice on citizen watch groups
- Recommendations for programs to monitor local waterways
- Assistance to the Conservancy for developing a runoff water quality sampling program and reporting. This will include developing a list of parameters to test based upon basin land use and recommendations from programs across the nation testing similar urban stormwater runoff.

When Glenwood Springs must develop an NPDES program, contact should be made with Phase I and II communities to discuss potential citizen forums and groups. Local River Watch programs in the Valley sponsored by the Conservancy, the City and the River District are excellent forums for education. The five educational tri-fold brochures shown in the Appendix and discussed in the previous section are great materials to present at these forums.

7.1 Educational Programs and Monitoring

The environmental education program initiated by the Roaring Fork Conservancy during the 1997/1998 school years has been expanded to include water monitoring activities and more in-depth focus on riparian and wetlands ecology. The Conservancy is implementing additional water quality monitoring activities and programs that focus on maintaining healthy aquatic and riparian ecosystems. Monitoring, which is based on the River Watch (Colorado Division of Wildlife Rivers of Colorado Water Watch Network) protocol, is addressing potential stormwater runoff constituents, such as suspended solids, nitrogen, phosphorous, bacteria, and dissolved metals. These monitoring activities are providing students with hands-on experience in measuring the effects of development. The River Watch monitoring protocol, which covers testing of pH, dissolved oxygen, total alkalinity, and hardness, is generating data for the evaluation of water quality in stormwater conduits. Additionally, the project will educate the general public about practices that minimize or improve stormwater runoff.

7.2 Water Quality Sampling

Urban stormwater runoff will pick up pollutants on the ground and convey them into the receiving waterways – the Roaring Fork River and Colorado River. Even though the source of pollutants may be a long distance from the rivers, the hard pipe storm drain network will efficiently carry these contaminants directly to the river. These pollutants degrade the receiving waters and reduce the quality of the pristine environment in Glenwood Springs. Just as Glenwood Springs would not allow raw sewage to be dumped into the rivers, the community should not allow direct runoff of stormwater from developed property without stormwater controls (i.e., water quality detention basins).

Exhaustive nation-wide studies on urban stormwater runoff by the EPA's National Urban Runoff Program (NURP) has concluded the following:

- The concentrations of pollutants in runoff from residential and commercial developments are roughly equivalent.
- The degree of basin imperviousness is correlated with pollutant loading.
- Seasonal variations are important (spring and winter pollutant concentrations are highest in snowy climates; the "first flush" from a half-inch of runoff contains the highest concentrations of pollutants in more arid regions).

Typical concentrations of pollutants for various land uses are shown in Table 8. These figures were developed through extensive water quality monitor programs in the Denver Metropolitan area. The City of Glenwood Springs likely has similar pollutant loading in its stormwater runoff.

Table 8
Land-Use Average Storm Runoff Event Mean Concentrations of Runoff in the Denver Metropolitan Area

Data Source: Urban Drainage & Flood Control District Criteria Manual, Volume 3

Constituent	Units	Industrial	Commercial	Residential	Undeveloped
Total Suspended Solids	(mg/L)	399	225	240	400
Total Dissolved Solids	(m/L)	58	129	119	678
Biochemical Oxygen Demand	(mg/L)	29	33	17	4
Chemical Oxygen Demand	(mg/L)	232	173	95	72
Total Nitrogen	(mg/L)	2.7	3.3	3.4	3.4
Total Kjeldahl Nitrogen	(mg/L)	1.8	2.3	2.7	2.9
Nitrate plus Nitrite	(mg/L)	0.91	0.96	0.65	0.50
Total Phosphorus	(mg/L)	0.43	0.42	0.65	0.40
Dissolved Phosphorus	(mg/L)	0.20	0.15	0.22	0.10
Cadmium, Total Recoverable	(µg/L)	3	1	Below Detection	Below Detection
Copper, Total Recoverable	(µg/L)	84	43	29	40
Lead, Total Recoverable	(µg/L)	130	59	53	100
Zinc, Total Recoverable	(µg/L)	520	240	180	100

7.3 Stormwater Runoff Monitoring Sites

In order to get a more specific idea of pollutant types and degree of loading in the Glenwood Springs area, future monitoring of stormwater runoff in Glenwood Springs is proposed. As previously described in the report, there are several well-defined representative runoff points, covering most of the City's runoff area, which can be tested during storm events. The eleven outfall locations are shown on the six Glenwood Springs Stormwater Evaluation Plan maps in the Appendix. The sites described represent the best points within the City of Glenwood Springs to monitor stormwater quality and quantity during runoff periods. Subbasins have been delineated for each design point to represent the drainage area that was not originally delineated in the 1982 study. The area shown on the maps for Subbasins 1 through 11 represent the area of the subbasin only. The total drainage area for the design point would include tributary subbasins as well. Brief descriptions of the prospective monitoring points are as follows:

Design Point 1

Design Point 1 (DP1) and Subbasin 1 are located in West Glenwood, west of the Glenwood Springs Mall, as indicated on Sheet 1 of 6. The approximate area of Subbasin 1 is 42.7 acres. The area contributing to DP1 includes a majority of Subbasins N-2, N-4 and N-7 and all of Subbasin 1. Specifically, the basin includes the West Glenwood Mall and surrounding parking lots, the undeveloped lot north of the mall, the residential neighborhood north of the mall beyond the City limits, and undeveloped mountainside. The basin extends from Highway 6 on the south, to the natural basin ridgelines, and from properties along Mel Ray Road to Storm King Road. Development within the basin includes retail and commercial in the lower portion, single family residential in the middle portion, and undeveloped mountainside in the upper portion. Stormwater runoff surface flows to inlets located in the north and south mall parking lots, which are conveyed via pipe to a junction point located at the southwest corner of the mall property. Flows are then carried via a 42" reinforced concrete pipe west to the outfall in the Mitchell Creek culvert. The recommended monitoring point for this basin is at the 42" RCP outfall where it connects to the 72" corrugated metal pipe Mitchell Creek culvert that runs under Highway 6 and Interstate 70. The 42" pipe outfall is approximately 20 feet downstream of the upstream end of the 72" culvert. Access to the monitoring point can be obtained from Highway 6 by entering the 72" culvert in Mitchell Creek on the north side of the road.

Design Point 2

Design Point 2 (DP2) and Subbasin 2 are located in West Glenwood near the Midland Bridge as shown on Sheet 1 of 6. The approximate area of this subbasin is 41.8 acres. The area contributing to DP2 encompasses portions of Subbasins N-7 and N-9 and all of Subbasin 2. Specifically, the basin includes the I-70 interchange and developed land north of I-70. The basin extends from the I-70 eastbound ramps to the natural basin boundary ridgelines, and from properties along Soccer Field Road to properties along Mel Ray Road. Development within the basin includes commercial in the lower portion, primarily single family residential in the middle, and undeveloped mountainside in the upper portion. The stormwater runoff collection system consists of overland swales that convey flows to inlets along Highway 6, culvert pipes carrying flows to the interchange detention ponds, and a storm sewer system collecting additional interstate runoff and conveying it to the ultimate outfall in the Colorado River. The recommended monitoring point is at the 30" RCP outfall located near the north abutment of the

Midland Bridge on the west side of the bridge. The outfall has a concrete headwall and flap gate. Access to the monitoring point can be obtained from the access road to the gas station northeast of the Midland Bridge, then by walking down the hillside to the headwall.

Design Point 3

Design Point 3 (DP3) and Subbasin 3 are located on the north side of Red Mountain near the Community Center as indicated on Sheet 2 of 6. The approximate area of Subbasin 3 is 159.9 acres. The area contributing to DP3 includes portions of Subbasins W-18 and W-19 and all of Subbasin 3. Specifically, the basin includes the community center, a portion of the railroad, and the undeveloped mountainside, which is scarred from recent wildfires. Basin 3 extends from Devereaux Road to the natural ridgelines on the mountainside, and to just east of the main community center building on the east. Development within the basin includes railyard in the lower portion, a community center in the middle portion, and undeveloped mountainside in the upper portion. There is a high potential for residential, retail, and commercial development in this basin in the future. Stormwater runoff from the community center is collected in a detention pond, then outfalls via culvert pipe on the north side of Midland Avenue. Roadway and rail runoff is added to a 54” RCP culvert which ultimately outfalls to the Colorado River. The recommended monitoring point is at the 54” RCP outfall located north of Devereaux Road beyond the fenced yard. The pipe outfall is in poor conditions and has accumulated a lot of debris. Access to the monitoring point is best obtained by starting from Devereaux Road, walking along the west side of the fence to the end of the fence, then heading east along the sideslope to the outfall. Look for a collection of rock, concrete and debris for the culvert end.

Design Point 4

Design Point 4 (DP4) and Basin 4 are located near the Devereaux Road Bridge as indicated on Sheet 2 of 6. The approximate area of this Basin is 13.4 acres. The area contributing to DP4 includes the CDOT facilities and parking lot, a potion of the interstate, and undeveloped land north of I-70. Discharge from the basin includes hot springs. The basin extends from Highway 6 to Centennial Street, and from west of the CDOT property to the easternmost CDOT building. Development within Basin 4 includes industrial in the lower portion, highway in the middle portion, and undeveloped land in the upper portion, which has the potential for industrial development. The stormwater runoff collection system consists of CDOT inlets near the interstate and storm sewer, picking up parking lot runoff and discharging directly to the Colorado River. The recommended monitoring point is at the 24” CSP outfall south of Centennial Street and east of the large spoil mounds. Access to the monitoring point can be obtained by starting at the parking lot off Centennial Street and walking along the grassed yard on the west side of building just east of the spoil mounds. Look for steam rising from the end of the pipe due to the hot springs water.

Design Point 5

Design Point 5 (DP5) and Basin 5 are located near the Devereaux Road Bridge as indicated on Sheet 2 of 6. The approximate area of the basin is 9.2 acres. The area contributing to DP5 includes a portion of the CDOT facilities, a portion of the interstate and undeveloped land north of I-70. Basin 5 extends from Highway 6 to Centennial Street, and from the easternmost CDOT building to Devereaux Road. Development within the basin includes industrial in the lower portion and undeveloped land in the upper portion, which has the potential for industrial development in the future. The stormwater runoff collection system consists of CDOT inlets near the interstate and a storm sewer that leads to a grass-lined swale. Flows are picked up by pipe at the end of the swale and conveyed to the ultimate discharge in the Colorado River. The recommended monitoring point is at the 36" CMP outfall located near the north abutment of the Devereaux Road Bridge on the west side of the road. Access to the monitoring point can be obtained from the parking lot off Centennial Street and following the grass swale adjacent to Devereaux Road towards the river.

Design Point 6

Design Point 6 (DP6) and Basin 6 are located near the Grand Avenue Bridge as shown on Sheet 3 of 6. The area contributing to DP6 includes the north portion of downtown Glenwood along the Grand Avenue corridor. The basin extends from 7th Street to the 12th Street Channel, and from the centerlines of Grand Avenue and Colorado Street to Cooper Avenue. The approximate area of basin 6 is 19.5 acres. Development within the basin includes retail and commercial with some single family residential. The stormwater runoff collection system consists of gutters and crosspans directing flows to inlets in the lower portion of the basin, and a storm sewer system with multiple laterals, which ultimately discharges to the Colorado River. The recommended monitoring point is at the 36" CMP outfall with concrete rundown located on the west side of the Grand Avenue bridge near the south abutment. Access to the monitoring sampling point can be obtained by foot from 7th Street underneath the bridge, walking down to and crossing the railroad tracks. Look for the concrete rundown.

Design Point 7

Design Point 7 (DP7) and Subbasin 7 are located west of the Glenwood Springs High School track as indicated on Sheet 4 of 6. The approximate area of Subbasin 7 is 20.7 acres. The area contributing to DP7 includes Subbasins E-5, E-6, E-7, E-10 and 7. Specifically, the basin includes a majority of downtown Glenwood and undeveloped mountainside. The basin extends from a ridge between 12th and 13th Streets to 22nd Street, and from Grand Avenue and the railroad tracks to the natural basin boundaries on the east. The approximate area of the basin 7 is 270.8 acres. Development within the basin includes retail and commercial in the lower portion, single family residential in the middle, and undeveloped mountainside in the upper portion. The stormwater runoff collection system consists of curb and gutter carrying flows to inlets along Grand Avenue and a storm sewer system conveying flows under Grand Avenue to a junction at the intersection of Grand Avenue and Park Drive. The storm sewer then carries flows under Park Drive and under the railroad tracks and an open field to the ultimate discharge in the Roaring Fork River. The recommended monitoring point is at the 42" RCP outfall located next to a field on the west side of the railroad tracks along the south property line of the high school extended. Access to the monitoring point can be obtained by starting at the intersection of Park Drive and Roaring Fork Drive, then by foot crossing the railroad tracks, bike path, maintenance road, and the field towards the river. Look for the concrete headwall structure near the water's edge.

Design Point 8

Design Point 8 (DP8) and Subbasin 8 are located west of the Glenwood Springs High School track as indicated on Sheet 4 of 6. The approximate area contributing to Design Point 8 is 194.1 acres. The area contributing to DP8 includes Subbasins E-5, E-6, E-7, E-10 and 8. Specifically, the basin includes a majority of downtown Glenwood and undeveloped mountainside. The basin extends from a ridge between 12th and 13th Streets to 22nd Street, and from Grand Avenue and the railroad tracks to the natural basin boundaries on the east. Development within the basin includes retail and commercial in the lower portion, single family residential in the middle, and undeveloped mountainside in the upper portion. The stormwater runoff collection system consists of curb and gutter carrying flows to inlets along Grand Avenue and a storm sewer system conveying flows under Grand Avenue to a junction at the intersection of Grand Avenue and Park Drive. The storm sewer then carries flows under Park Drive and under the railroad tracks and an open field to the ultimate discharge in the Roaring Fork River. The recommended monitoring point is at the 42" RCP outfall located next to a field on the west side of the railroad tracks along the south property line of the high school extended. Access to the monitoring point can be obtained by starting at the intersection of Park Drive and Roaring Fork Drive, then by foot crossing the railroad tracks, bike path, maintenance road, and the field towards the river. Look for the concrete headwall structure near the water's edge.

Design Point 9

Design Point 9 (DP9) and Basin 9 are located near Safeway as indicated on Sheet 4 of 6. The approximate area of the subbasin is 5.6 acres. The area contributing to DP9 includes the Safeway rooftop and parking lot and fringe, mostly impervious areas. Basin 9 extends from the south edge of the Park Drive properties to Wendy's, and from the west Safeway property line to Grand Avenue. Development within the basin is primarily commercial. Stormwater runoff surface flows over the parking lot to a single inlet with a water quality skimmer and is conveyed via pipe to the ultimate discharge in the Roaring Fork River. The recommended monitoring point is at the 18" CMP outfall located west of the railroad tracks northwest of Safeway and runs along the surface of the sideslope, dropping approximately 30 feet before discharging. Access to the monitoring point can be obtained by starting in the Safeway parking lot, walking along the south side of the building and around the end of the chain link fence, crossing the railroad tracks and heading north along the bike path to a point across from the inlet structure, then locating the exposed pipe on the west side of the path and following the pipe down the sideslope to the end.

Design Point 10

Design Point 10 (DP10) and Subbasin 10 are located between the intersection of Grand Avenue and Highway 82 and the Sunlight Bridge as indicated on Sheet 5 of 6. The approximate area of the subbasin is 6.5 acres. The area contributing to DP10 includes the area between Highway 82 and the river. The basin extends from the Grand Avenue/Highway 82 intersection to Oriole Street, and from Meadowlark Lane to the Highway 82 centerline. Development within the basin includes residential and commercial in the lower portion and railroad and highway in the upper portion. The stormwater runoff collection system consists of a CDOT inlet near the highway, a pipe under the railroad and trailer park that collects Grand Avenue runoff, and a pipe in Oriole Street that collects parking lot and residential runoff and ultimately discharges in the Roaring Fork River. The recommended monitoring point is at the 24" RCP outfall located directly west of Meadowlark Lane along Oriole Street extended. Access to the monitoring point can be obtained by starting at the intersection of Oriole Street and Meadowlark Lane and heading west by foot along the grassed easement to the top of the riverbank, just west and north of a large circular at-grade lift station cover.

Design Point 11

Design Point 11 (DP11) and Subbasin 11 are located near the abandoned Road 156 Bridge south of the Sunlight Bridge as indicated on Sheet 6 of 6. The approximate area of Subbasin 11 is 86.6 acres. The area contributing to DP11 includes a majority of Subbasins E-16 and E-17 and all of Basin 11. Specifically, the basin includes the south Walmart parking lot, the shopping center south of Walmart and surrounding parking lots, the multifamily residential units south of the shopping center, Highway 82 and the railroad tracks, Rosebud Cemetery, and undeveloped mountainside. The basin extends from Walmart and the north edge of the cemetery to the south edge of the multi-family residential development, and from Grand Avenue to the natural basin boundaries. Development within the basin includes commercial and multi-family residential in the lower portion and undeveloped mountainside in the upper portion. Stormwater runoff travels down a rock rundown on the mountainside southeast of Walmart, and then surface flows over the parking lot to a single inlet in the southwest corner of the Walmart parking lot. Flows are then conveyed via storm sewer system along Blake Street collecting surface flows from Blake Street and multiple parking lots to a minor detention pond on the east side of Highway 82. A culvert carries flows across Highway 82 and the railroad tracks, dumping them into a half-42” CMP culvert which runs south then west along the north cemetery property line. A 24” CMP picks up the flows in addition to collecting Grand Avenue and runoff from the cemetery then carries the flows west to the ultimate discharge in the Roaring Fork River. The recommended monitoring point is at the 24” CMP outfall located near the east abutment of the abandoned Road 156 Bridge on the north side of the bridge. Access to the monitoring point can be obtained from the intersection of Grand Avenue and Road 156 and walking down the riverbank near the bridge abutment.

7.4 Monitoring Plan

The stormwater runoff monitoring plan will incorporate the testing of runoff at some or all of the sites described above during storm events of various magnitudes. Depending on the time of year, the runoff will be generated by rain or by snowmelt. Precipitation data will assist in determining when to monitor the size of the storm event, the dilution factor, and the stormwater discharge rate and quantity.

Grab samples will be taken at each selected site and analyzed at a lab. Samples will be analyzed for constituents including suspended sediments, dissolved oxygen, alkalinity and hardness, pH, temperature, nutrients and dissolved metals. Monitoring will occur throughout the year. Some areas are strongly influenced by the rivers and by irrigation ditch runoff, therefore there may also be more frequent monitoring during the spring runoff period.

7.5 Monitoring Parameters

Water quality testing can be very expensive, and it is important to clearly define the goals of sampling before beginning a program. Check current NPDES requirements for stormwater outfall monitoring and testing. Regulation 38 of the Colorado Surface Water Standards for Roaring Fork River (Class I, Cold Water) suggest the following testing, however this is not a requirement for the City at this time. The following list is provided as a suggestion for possible monitoring, along with approximate laboratory costs for testing. Additional expense will be incurred for transporting samples to the lab and field equipment and time.

General Parameters

- Temperature (field)
- pH (field or $7 lab)
- Dissolved Oxygen (field)
- Hardness ($8 lab)
- Calcium
- Fecal Coliform
- Total Suspended Solids (TSS)
- Total Dissolved Solids (TDS)

General Inorganics (EPA #9056) ($70 lab)

- Bromide
- Chloride
- Fluoride
- Nitrate
- Nitrite
- Orthophosphate
- Sulfate

Dissolved Metals (EPA #6010) ($149 lab)

- Arsenic
- Cadmium
- Chromium
- Copper
- Iron
- Lead
- Manganese
- Nickel
- Selenium
- Silver
- Zinc
- Mercury (may not be necessary)

Total Oil & Grease (TOG)

Total Petroleum Hydrocarbons (TPH)

8. TASK #3: ILLICIT DISCHARGE DETECTION AND ELIMINATION

Any discharge that is not composed entirely of stormwater, and has not been authorized under a discharge permit issued by the State of Colorado is considered an *illicit discharge*. Typically, this relates to combined sanitary sewer discharges connected with storm drains. Storm events can overwhelm the capacity of a combined sanitary sewer system and cause a direct discharge of untreated wastewater to the stream system. Illicit discharges also include dumping pollutants into the local inlets and storm drains.

Illicit connections can be as simple as indoor floor drain connections to the storm system. Only outdoor drains exposed to the atmosphere should be allowed to directly discharge to the stream system. Typical types of illicit discharges are listed below:

Sources of Illicit Discharges:

1. Sanitary Wastewater
   a. Untreated wastewater
   b. Effluent from improperly operating or improperly designed septic tanks
   c. Overflow of sanitary sewerage systems
2. Automobile Maintenance and Operation
   a. Car washes
   b. Oil disposal
   c. Fluids flushing
3. Landscape Irrigation - Fertilizers, pesticides and herbidices
   a. Direct spraying
   b. Over application
4. Other sources
   a. Laundry wastes
   b. Cooling waters
   c. Metal plating
   d. Dewatering of construction sites
   e. Washing of concrete
   f. Contaminated sump pump discharges
   g. Improper disposal of household toxic wastes
   h. Spills from roadway and other accidents
   i. Chemical, hazardous materials, garbage, and sanitary sludge

During our field investigation, we identified outfalls with continuous discharges during dry weather conditions. This can be the result of intercepted groundwater or geothermal spring discharges. Hot springs discharges in Glenwood Springs were not evaluated under this contract.

Other findings of illicit discharges in Glenwood Springs are shown in the accompanied photo pages.

9. TASK #4: CONSTRUCTION SITE STORMWATER RUNOFF CONTROL

The goals of this section are to provide the following:

- Preventative Controls
- Erosion Controls
- Sediment Controls
- Drainageway Controls
- Non-sediment Controls

Management of construction site stormwater runoff pertains to implementation of ***Best Management Practices*** (BMPs). BMPs represent the best available approaches to minimize site erosion and the level of the sediment and other pollutants leaving the site. Construction (temporary) BMPs are site controls implemented to manage stormwater runoff from disturbed lands. These measures are temporary and typically may include the following at a minimum:

- Sedimentation basins
- Silt fencing
- Straw bales
- Inlet protection
- Vehicle gravel tracking pads
- Soil stabilization with seed and mulch

9.1 Construction Site Erosion Control Measures

Existing City policies address the use of Best Management Practices in construction site management. Grading permits are required to monitor and control earthwork activities that could lead to water erosion. Permanent stormwater management practices that have been implemented in the City of Glenwood Springs include dry wells and retention ponds, as well as single and double-chambered septic systems. Construction management stormwater programs include sequencing of earthwork activities to minimize runoff, use of straw bales and silt fencing to retard sediment movement, and revegetation of disturbed sites.

Permit applications and regulations were developed by the City of Glenwood Springs to regulate construction activities. The following regulations seek to minimize the transport of sediment and pollutants on disturbed sites during construction:

- Ordinance 36, Series 2001 – Amendment to Stormwater Drainage Regulations requiring Stormwater Quality controls
- Application for Excavation and Grading Permit
- Erosion and Sediment Control, Stabilization and Revegetation Criteria (070.030.050)

These control measures address the Colorado Department of Public Health and Environment's requirement to have a stormwater management plan for any development disturbing more than one acre. The requirement for erosion control under the Phase I NPDES regulations affected sites of 5 acres or more, but now has been reduced to developments of one acre or more under implementation of the Phase II program.

9.2 Recommended Construction BMPs

Control of construction activities is a critical activity within stormwater runoff management. During the relatively short period of time when land is converted from undeveloped to urban uses, a significant amount of sediment can erode from a construction site and be transported to adjacent properties and to receiving waters. If measures are not taken to reduce erosion and to capture sediment in runoff from construction sites, damage can occur to offsite areas and to aquatic habitats in the receiving water system. Figure 1 is a "BMP Toolbox" developed by Wright Water Engineers for the Northwest Colorado Council of Governments (NWCCOG). It provides a menu of options for construction site stormwater controls. Basic construction stormwater controls should address the following:

1. Minimize erosion on the site through the following:
   - Phase construction – do not disturb the entire site at one time
   - Install erosion and sediment control measures before site grading
   - Implement soil stabilization measures as soon as possible
   - Provide temporary and permanent revegetation

2. Minimize sediment leaving the site by:
   - Manage stormwater runoff flows
   - Utilize vehicle tracking pads
   - Protect adjacent properties from sediment-laden runoff
   - Protect storm sewer inlets from entry of sediment-laden water
   - Divert off-site runoff around the construction site

3. Capture pollutants on-site by:
   - Construct water quality ponds or sedimentation basins to store at least the volume from a half-inch rainstorm for at least 12 hours
   - Construct detention basins for larger storm events
   - Release stormwater at the rate that would occur in an undeveloped setting

VTC	VEHICLE TRACKING PAD	A gravel pad, located at the points of vehicular ingress and egress on a construction site, to reduce the mud transported onto roads and paved areas.
STB	STRAW BALE BARRIER	A temporary sediment barrier composed of anchored straw bales placed across or at the toe of a slope to intercept and detain sediment and decrease flow velocities from small drainage areas; applicable where sheet and rill erosion potential is low to moderate.
SBB	SANDBAG BARRIER	Temporary stabilization of ditches by placement of sandbags perpendicular to flow. Accompanied by a depression upstream for sediment retention. Good for use where soils are difficult to excavate, in areas of shallow bedrock, and in steep drainages.
SF	SILT FENCE	A temporary sediment barrier constructed of posts, filter fabric and, in some cases, a wire support fence, placed across or near the toe of a slope or in a minor drainageway to intercept and detain sediment and decrease flow velocities from drainage areas of limited size; applicable where sheet and rill or small concentrated flows may be a problem.
ST	SEDIMENT TRAP	A small ponding area, formed by constructing an earthern embankment with a gravel outlet across a drainage swale, to detain sediment-laden runoff from small disturbed areas for enough time to allow most of the sediment to settle out.
SB	SEDIMENT BASIN	A basin with a controlled stormwater release structure, formed by constructing an embankment of compacted soil across a drainageway, to detain sediment-laden runoff from disturbed areas greater than 5 acres for enough time to allow most of the sediment to settle out. Can be constructed only where there is sufficient space and appropriate topography. Temporary unless designed as a permanent pond.
BB	BRUSH BARRIER	A temporary sediment barrier composed of limbs, weeds, vines, root matter, soil, rock and other cleared materials pushed together to form a berm; located across or at the toe of a slope to intercept and detain sediment and decrease flow velocities during grading operations and removed at the time of final grading.
CD	CHECK DAM	Small, temporary berms constructed across drainageways to reduce the velocity of concentrated flows, reducing erosion of the swale or ditch. Limited to use in small open channels which drain small areas; should not be used in live streams.
TP	TREE PRESERVATION & PROTECTION	Protecting existing trees from mechanical and other injury during land disturbing and construction activity to insure the survival of trees where they are effective for erosion and sediment control and provide other environmental and aesthetic benefits.
GS	GRASS LINED SWALE	The establishment of appropriate vegetation in constructed channels to limit channel erosion and stabilize channel bottom.
PS	PERMANENT SEEDING	Establishment of perennial vegetative cover by planting seed on rough-graded areas that will not be brought to final grade for an extended time or where permanent, long-lived vegetative cover is needed on fine-graded areas. Used in conjunction with heavy mulching.
PP	PERMANENT PLANTING	Establishment of woody vegetation on rough-graded areas that have been permanent seeded or sodded where permanent, long-lived vegetative cover is desired on fine-graded areas. Used in conjunction with mulching.
TM	TEMPORARY MULCHING	Use of crimped straw, wood chips, sawdust, etc., to cover the denuded surface shortly after clearing and grubbing, grading, and construction activities. Mulching is the most effective and important erosion control practice to be used.
PM	PERMANENT MULCHING	Use of wood chips, stone, bark etc., to cover the finished graded surfaces after construction activities. Mulching within 3 days of operations to eliminate erosion and conserve moisture for plantings to enhance growth. Part of the final landscaping including drainageways, swales, etc. Used with permanent planting.
IP	INLET PROTECTION	The installation of various kinds of sediment trapping measures around inlets, culverts and structures prior to permanent stabilization of the disturbed area; limited to small drainage areas and not intended to control large, concentrated stormwater flows.
DD	DIVERSION DIKE	A ridge of compacted soil located at the top or base of a sloping disturbed area to divert off-site runoff away from unprotected slopes to a stabilized outlet, or to divert sediment-laden runoff to a sediment trapping structure.
WB	WATER BAR	Small berm and ditch combination approximately 18 inches in height and laid across a slope at 45° to 60° to reduce the velocity of concentrated flows, reducing erosion of a slope, swale or ditch. For use as a semi-permanent structure on trails, ski runs and seasonal access roads.
FB	FILTER BERM	A temporary berm or ridge constructed of loose gravel, stone, or crushed rock which slows and filters flow. May be used to direct runoff to a stable outlet, or filter stormwater in high traffic areas.
GM	GEOTEXTILE MATTING	Strong man-made mattings used to stabilize the flow on high velocity channels and swales and recently planted slopes. Also used as a reinforcement between courses on road work over soft areas. Recommended for use in retaining wall and fill slope construction as a tie-back into native materials.
NM	NATURAL MATTING	Biodegradeable materials, such as straw and excelsior bound in netting and impregnated with seed, are used on slopes where rill and sheet erosion may be a problem and where seed and mulch will not be effective. Can be utilized in temporary and permanent seeding solutions as necessary.
SC	TEMPORARY STREAM CROSSING	A temporary structural span across a stream to provide vehicular access to construction activity on either side of stream while keeping sediment out of the stream and preventing damage to the channel and banks. Used in conjunction with other measures to avoid sedimentation of the receiving water.
SR	SURFACE ROUGHENING	Grading practices such as stair-stepping, grooving slopes or leaving slopes in a roughened condition by not fine-grading them. Reduces runoff velocity, provides sediment trapping and increases infiltration; all of which facilitate establishment of vegetation on exposed slopes.
FCS	FLUSH CUT STUMPS	During timber removal operations trees are cut close to the ground to allow for crossing by vehicles and persons while leaving the root mass in place to retain the soil. Applicable on steep slopes and where fine grading and landscaping are not required. Used in conjunction with mulching, matting and seeding to further control erosive forces.
SL	SLOPE DRAIN	A flexible conduit, used before permanent drainage structures are installed; intended to convey concentrated runoff safely from the top to the bottom of a disturbed slope without causing erosion on or below the slope.
DV	PERMANENT DIVERSION	A permanent channel with a ridge on the lower side constructed across a slope to reduce slope length and intercept and divert stormwater runoff to a stabilized outlet to prevent erosion on the slope.
OP	OUTLET PROTECTION	The installation of paved or rip-rap channel sections and/or stilling basins below storm drain outlets to reduce erosion from scouring at outlets and to reduce flow velocities before stormwater enters recieving channels below these outlets.
RR	RIP-RAP PROTECTION	A permanent, erosion-resistant ground cover of large, loose, angular stone installed wherever soil conditions, water turbulance and velocity, expected vegetative cover, etc., are such that soil may erode under design flow conditions.
CRS	CONSTRUCTION ROAD STABILIZATION	Temporary stabilization with stone high traffic areas prone to erosion immediately after grading to reduce erosion potential damage caused by vehicles during wet weather and to prevent having to regrade permanent roadbeds between initial grading and final stabilization.
DC	DUST CONTROL	Reducing surface and air movement of dust during land disturbance, demolition or construction activities in areas subject to dust problems in order to prevent soil loss and reduce the presence of potentially harmful airborne substances. Includes the covering of soil stock piles and construction materials
TSP	TOPSOIL PROTECTION	Stripping, stockpiling and protecting topsoil for later use in permanent landscape activities. Stockpiles are covered with sheeting, mulch and/or seed and surrounded by a containment berm to protect them from erosive forces. Periodic "turning" of the piles is required to maintain endemic microbial soil organisms.
LS	LEVEL SPREADER	An outlet for dikes and diversions consisting of an excavated depression constructed at near zero grade across a slope to convert concentrated, sediment-free runoff to sheet flow and release it onto areas of undisturbed soil stabilized by existing vegetation.
CWD	CLEAR WATER DIVERSION	A temporary re-routing of a watercourse through a sluice or tube to reduce the amount of clean water collecting sediments from active construction operations.
INF	INFILTRATION TRENCH	A semi-permanent sub-surface drain that allows for storm water to be absorbed by the ground in a ponded area. Typically a rock and fabric lined trench on the down gradient side of a road fill or in an open area away from the roadway.
SD	SUB-SURFACE DRAINS	A perforated conduit installed beneath the ground to intercept and convey groundwater. Prevents sloping soils from becoming excessively wet and subject to sloughing.
WDS	WATERWAY DROP STRUCTURE	A permanent structure or series of structures designed to "step" water flow down a slope without causing channel erosion; applicable in natural or man-made channels with long, relatively steep reaches.

NOTE: ADDITIONAL PRACTICES NOT SHOWN HERE CAN BE IMPLEMENTED BASED ON FIELD OBSERVATIONS AND ADJUSTMENTS FOR WEATHER, SEASON AND UNFORESEEN SITE CONDITIONS. CONTACT YOUR LOCAL PLANNING OFFICE FOR SPECIFIC SITE RECOMMENDATIONS AND FURTHER ASSISTANCE.

USE THESE CONVENIENT SYMBOLS AND DESCRIPTIONS WHEN DEVISING AN EROSION CONTROL PLAN FOR THE INTENDED PROJECT. THE SYMBOLS ARE NATIONALLY ACCEPTED WHILE THE DESCRIPTIONS ARE TAILORED FOR MOUNTAIN DRIVEWAY CONSTRUCTION.

WWE

WRIGHT WATER ENGINEERS, INC.
2490 W. 26TH AVE. SUITE 100A
DENVER, CO 80211
(303)480-1700

DESIGN -
DRAWN CMC
CHECK JKC/KAL
DATE 4/99

MOUNTAIN DRIVEWAY EROSION and SEDIMENT CONTROL BEST MANAGEMENT PRACTICES "EROSION CONTROL TOOLBOX"

FIGURE ONE

10. TASK #5: POST CONSTRUCTION STORMWATER MANAGEMENT

Permanent stormwater controls play an important role in long-term management of runoff water quality. Development increases the imperviousness of a site, which generally increases the frequency and peak discharge of stormwater runoff. These factors can cause harmful impacts to downstream property and receiving waterways. Therefore, municipalities implement ordinances and stormwater controls to mitigate potential impacts from development.

The following tasks have been completed for Glenwood Spring to improve Post-Construction Stormwater Management:

1. Existing BMP's, such as detention ponds, sedimentation ponds, water quality baffles and dry wells were inventoried and identified on the base mapping.
2. Recommendations have been included for structural options that will improve runoff water quality, such as retention ponds, detention ponds, disconnecting impervious surfaces, filters, sanitary sewer improvements, isolating potential contaminants from mixing with stormwater, etc.
3. Recommendations for non-structural options have been described for improving runoff. This includes assisting the City with their evaluation of their drainage ordinances and policies.
2. Cursory hydrology has been provided to help evaluate the adequacy of existing stormwater infrastructure, and provide information to assist in the sampling program. Climatological information was gathered for the Glenwood Springs area to understand rainfall patterns and the occurrence of typical runoff events. At an elevation of 5,700 feet, Glenwood Springs's peak stormwater discharges are dominated mainly by rainfall, rather than pure snowmelt. The hydrology study evaluated discharge rates for the 10-year, 25-year storm and the 100-year storm events.

10.1 Categories of Stormwater BMPs

Stormwater improvements can be integrated into the community through local site controls and/or through regional planning. Local site controls are the responsibility of each landowner or developer to manage the quantity and quality of stormwater leaving the site. Regional controls must be master-planned into the community to manage stormwater before it outfalls into the major drainageways of the Roaring Fork or Colorado Rivers. BMPs can also be thought of as non-structural or structural in nature. Non-structural BMPs refer to new or revised stormwater management ordinances, while structural BMPs refer to specific infrastructure recommendations. Examples of each of the subcategories are described below:

- Site Controls:
  - Minimize Directly-Connected Impervious Area (DCIA)
  - Utilize Swales and Biofilters
  - Reduce Site Imperviousness by Porous Pavement and Parking Blocks
  - Promote Infiltration Through Trenches and Holding Basins

- Regional Controls:
  - Wet or Dry Stormwater Detention for Flood Control
  - Extended Detention for Water Quality Treatment of Stormwater Runoff
  - Holding Basins for Snow Removal Storage

- Non-Structural BMPs include the subcategories of pollution prevention BMPs and source control BMPs. Non-structural source controls are often methods to isolate pollutants from stormwater and may include enclosing potential pollutants to prevent mixing with stormwater. For example, drums of oil and grease may be kept in sheds to prevent stormwater from washing away pollutants. Other non-structural BMP's may include:
  - Administrative pollution prevention programs
  - Development of set-backs along receiving waterways
  - Ordinances regulating development of steep slopes where erosion can be prevalent
  - Stormwater quantity and quality ordinances
  - Routine street sweeping
  - Modified street maintenance practices to remove potential contaminants
  - Employee training with attention to improving runoff water quality
  - Careful material handling practices

- Structural BMPs include facilities constructed to passively treat urban stormwater runoff before it enters the receiving waters. Structural BMPs are facilities used to reduce runoff and/or remove constituents from runoff. Examples of structural BMPs include:
  - Water quality detention (both dry basins and wet ponds)
  - Wetlands
  - Porous pavement, and the use of vegetated zones
  - Snow storage facilities.

10.2 Recommended Permanent Stormwater BMPs

Basic permanent stormwater controls for developed sites should include the following:

1. Avoid direct discharge of stormwater to streams or other waterbodies.
   - Discharge direct runoff into stable, vegetated areas.
   - Attain on-site treatment of stormwater through use of Best Management Practices designed to detain or infiltrate the runoff and approved as part of the Stormwater Quality Control Plan.
   - Discharge stormwater to a conveyance structure designed to accommodate the flows with water quality treatment prior to discharge to a receiving waterway.

2. Minimize Directly Connected Impervious Areas to allow pollutants to settle or be filtered out of stormwater runoff by:
   - Daylight roof drains to grassy areas
   - Daylight storm pipes to grassy open channels
   - Grass swales for stormwater conveyance

3. Detain and Treat Runoff. Detention can be either on-site or regional in nature.
   - Design detention for minor and major storm events
   - Design conveyance facilities for the 100-year event
   - Stabilize channels
   - Achieve removal of pollutants by sizing dry detention basins to incorporate a 40-hour emptying time for a design precipitation event of 0.5 inches in 24 hours, with no more than 50% of the stored water being released in 12 hours. For drainage from parking lots, vehicle maintenance facilities, or other areas with extensive vehicular use, this practice may require the additional use of sand and oil grease trap or similar practices.
   - Maintain on-site detention facilities and drainage infrastructure.

4. Manage Snow Removal and Storage
   - Snow removal accumulates sand, oil and grease, metals, trash, pet wastes, and other pollutants found in urban stormwater. An area should be set aside for snow storage with controls to capture these pollutants.

10.3 Existing Ordinances and Regulations

The City of Glenwood Springs does not have a formal Drainage Criteria Manual, and has few existing ordinances and regulations specifically for drainage, as compared with many larger Front Range Phase I communities. Most of Glenwood's current regulations are focused on river setbacks, floodplains, geologic hazards or construction site erosion control measures. Only a few regulations pertain to post-construction permanent drainage controls. However, the City recently (2001) adopted Ordinance 36 to amend its stormwater drainage regulations to include *Stormwater Quality*.

River Setbacks

Development setbacks promote better water quality of stormwater runoff by maintaining separation from development and the receiving waterways. Article 070.030.030A1 requires that no improvement, building, structure, excavation, dumping or backfilling shall be placed, built, undertaken or approved within a 30 foot setback area measured horizontally from the high water mark of any river or live stream.

Protection of Riparian and Wetland Areas

If development is permitted in a riparian or wetland areas, the following development criteria from federal and state regulations apply:

- Any disturbed vegetation adjacent to wetland or riparian areas shall be re-vegetated as soon as possible.
- Adequate erosion control measures shall be incorporated in any development site plans. These measures shall include minimization of runoff velocities, diversion of runoff from areas with disturbed soil, development of drainage systems to handle concentrated or increased runoff, grading and construction sequencing to minimize soil exposure, and use of BMP's for construction site control.
- No activity shall be allowed which will increase stream sedimentation and suspension loads. Development shall maintain the minimum water quality standards established by CDPHE WQCC, Regulation No. 33, Classifications and Numeric Standards for the Upper Colorado River Basin and the North Platte River Basin.

10.4 NWCCOG Water Quality Protection Standards

The Northwest Colorado Council of Governments (NWCCOG) developed ***Water Quality Protection Standards*** to be used by small mountain communities. The *Water Quality Protection Standards* are a comprehensive state-of-the-art model ordinance for the protection of water quality from negative impacts of land development. It is a preventative approach to protect water quality and is intended to be used by all local governments within a watershed. This model ordinance is meant to be a single, stand alone section of a local government's land development code. A copy of the document is included in its entirety in the Appendix of this report for consideration by the City of Glenwood Springs.

The *Water Quality Protection Standards* are organized into nine specific topic areas:

1. Control of Erosion and Sedimentation;
2. Post-Construction Stormwater & Urban Runoff;
3. Slope Limitations;
4. Waterbody Buffer System;
5. Hazardous Materials Management;
6. Snow Storage;
7. Wastewater System Standards;
8. Water Quality Protection Standards Applicable Within Watershed District or Sensitive Area Overlay District; and
9. Enforcement and Penalties.

In summary, the following is a condensed list of drainage recommendations by the NWCCOG, and then a specific recommendations list for the City of Glenwood Springs:

Northwest Colorado Council of Governments Recommendations

1. Development of "Stormwater Quality Control Plans"
2. Disconnect Impervious Surfaces and Promote Infiltration (Glenwood Springs Ordinance 36, series of 2001)
3. Discharge 2 & 25-year Storm at Undeveloped Rates
4. Safely Convey 100-year Storm Event
5. Capture the first ½-inch of runoff and release over a 40-hour period

6. Stabilize channels against the 25-year event
7. Sweep Streets – Especially in Spring
8. Dedicate Holding Areas for Snow Removal

Glenwood Springs Recommendations

1. Maintain Existing Stormwater Facilities
2. Construct Regional Detention Ponds downstream of Developed Areas
3. Require New Development to Construct On-Site Detention and Water Quality Ponds, and Safely Convey Stormwater Runoff to Receiving Waterways
4. Route Off-Site Runoff Around Critical Facilities and Structures
5. Modify Existing Detention Pond Outlets for Water Quality Purposes
6. Develop a Drainage Infrastructure Master Plan
7. Hire a Regional Full-Time Erosion Control Inspector
8. Monitor Stormwater Runoff Water Quality
9. Adopt NWCCOG Stormwater Ordinances
10. Develop a detailed Drainage Criteria Manual

10.5 Post-Construction Stormwater Recommendations

The following is a list of recommended stormwater controls by category:

Site • Disconnect impervious surfaces • Require treatment of "First Flush" • Require detention for minor and major storm events (either 2 and 25, or 10 and 100-year storm events) • Promote infiltration on-site	**Regional** • Construct regional stormwater treatment ponds (see maps) • Enlarge existing detention ponds and modify outlets for water quality treatment of first ½-inch of runoff • Acquire and develop land for regional stormwater ponds at major outfalls to the rivers
Non-Structural • Adopt all or part of NWCCOG Water Quality Standard Ordinances • Sweep streets, especially in spring before big thaw • Unclog culverts and inlets • Maintain stormwater ponds • Educate the community on stormwater pollution prevention	**Structural** • Improve drainage conveyance system to handle a 100-year storm event • Reduce or mitigate the amount of impervious surfaces constructed by new development

10.6 Recommendations for Control of Mud and Debris Flows

Large parts of the City of Glenwood Springs are subject to flood hazards as the result of debris flows and mud floods originating from the numerous small gulches on the surrounding mountainsides. The hazard is most severe on the upper parts of the debris fans, but extends to lesser degrees to the lower fans. Debris flows and mud floods are physically much different than conventional water floods, and different engineering methods must be used to analyze them. It is not generally possible to avoid the hazard; therefore, the City and its residents must either endure the hazard or implement specific structural and nonstructural mitigation schemes.

Conveying the mud and debris directly to the river (12th Street Outfall) can protect the City but does not protect the water quality and ecosystems on the receiving streams. While the concept of storage of the runoff (sedimentation basins) is logical, most of the small basins do not contain good sites for large enough debris basins. The biggest limitation is available capacity, along with geotechnical and hydraulic problems in the gulches and fans. The most practical structural control systems for small basins combine elements of energy dissipation and conveyance. Runoff can be diverted, channelized, or piped to adequate locations for sedimentation. The Glenwood Ditch and the Atkinson Canal are ditches along both sides of the Roaring Fork River. These ditches can capture, redirect or treat water quality from normal storm events. However, reliance upon these ditches for major storm events can create problems by transferring drainage problems to other areas since both ditches are lined with homes. Damage can often be minimized by constructing small control overflow weirs and outfall chutes at design low points on the ditch banks, upstream from reaches that are likely to be blocked.

Debris basins also require very close attention to cleaning and maintenance. Should a storage facility be filled, overtopped, or caused to fail in any other manner, it could cause more damage than the debris flows and mud floods that it was designed to control by creating a second and potentially more powerful flood wave. Privately owned debris basins should be used only when control cannot be reasonably achieved by other means. They should be carefully and conservatively designed and should be used only when there is a responsible organization available to provide maintenance (City, private agency or homeowners group).

In summary, the City and its inhabitants should:

1. Be aware that the purpose of the planned measures is not necessarily to eliminate the hazard, but rather to reduce it to acceptable levels within practical limits.
2. Act in cooperation with other landowners and individuals to prepare contingency plans for watershed and channel stabilization in the event that brush fires or other destructive events occur within the area.
3. Remedy critical problems with local drainage on a spot basis. This includes irrigation ditch overflow problems and areas with water and mud damage problems on the lower parts of debris fans.
4. Establish criteria for drainage and erosion control, either specifically or by reference, in newly developing areas. Once established, the criteria should be strictly enforced.
5. Develop an overall stormwater drainage plan and to make a conceptual design of that drainage system

11. TASK #6: POLLUTION PREVENTION/GOOD HOUSEKEEPING FOR MUNICIPAL OPERATIONS

This control measure focuses on the City as a Phase II community (although Glenwood Springs is not yet required) to alter their own actions to help ensure a reduction in the amount of type of pollution entering the streams. This task examines stormwater controls for stormwater management of:

- Streets
- Parking Lots
- Open Spaces
- Vehicle Maintenance Areas
- Other Municipal Operations

Street sweeping and snow removal are common municipal operations that can impact the water quality of stormwater runoff. If performed regularly and managed to capture pollutants, these activities can positively impact stormwater runoff. Use of agents to improve travel on snow-covered streets, such as magnesium chloride, salt and sand is also considered under this control measure task. Measures can be implemented to capture these materials before they are discharged directly into the stream system.

This program also aims to reduce pollution by promoting spill prevention programs, control of reuse or recycle materials, proper storage of hazardous materials, and improvements to snow storage sites.

This program also promotes training of public employees to reduce stormwater pollution from municipal operations. Training would include pollution prevention, good housekeeping techniques, and waste recycling. The photo inventory (Chapter 5) identifies some observed problems at the Municipal Operations Center. Training materials are available from the EPA, Colorado Department of Public Health & Environment, and other Phase I communities.

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